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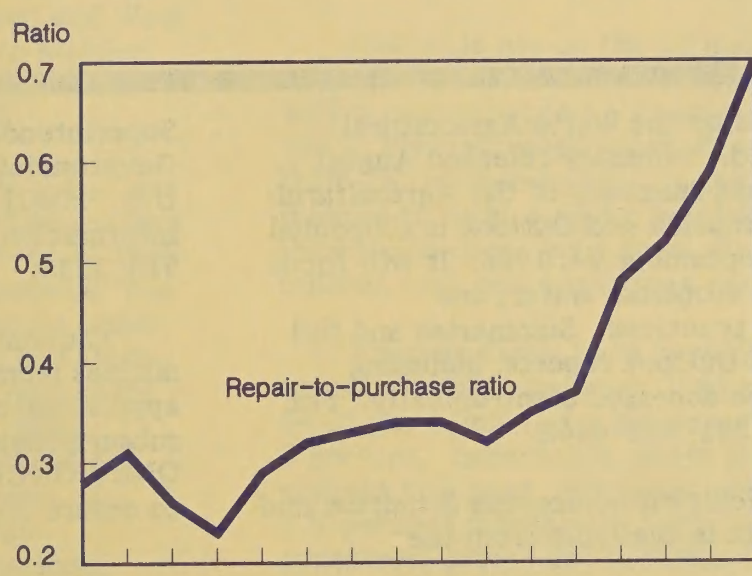
Agricultural Resources

Inputs
Situation and Outlook Report

Repairs Vs. Purchases of U.S. Farm Machinery



Machinery repair expenditures increase as farmers keep equipment longer

CONTENTS

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SUMMARY

Purchases of new and used farm equipment are expected to decline to between $4.8 and $5.1 billion in 1986, as U.S. farmers contend with a slightly higher debt-to-asset ratio, relatively stable net cash farm income, and higher real interest rates. Last year, farmers spent an estimated $5.68 billion on farm machinery, down 22 percent from 1984, marking the seventh straight year of reduced outlays.

For most farm machinery categories, unit sales of new equipment are projected to fall sharply this year. Sales of farm wheel tractors are forecast to drop 22 percent for 40–99 hp two-wheel-drive units and 33 percent for four-wheel-drive units, while sales of over-100-hp two-wheel-drive units may rise 5 percent. Sales of grain-harvesting equipment are anticipated to fall about a third from 1985, and most forage and haying equipment sales will be 11 to 21 percent lower. Despite declining unit sales for the major new farm machinery items, manufacturers were able to reduce May 1986 inventory-to-purchase ratios for several machinery categories.

During first-quarter 1986, U.S. farm machinery imports rose 7 percent from a year earlier, while exports fell 4 percent, leading to a record $41-million farm machinery trade deficit. Rising imports from Japan and West Germany, and declining exports to Mexico, Australia, and Saudi Arabia accounted for much of the trade balance deficit.

In 1985, farmers in the major corn- and soybean-producing States planted 46 percent of their corn acreage and 33 percent of their soybeans under reduced tillage systems. The Corn Belt had the largest percentage under reduced-till, while the Southeast and Delta had the smallest. Farmers went over their corn fields an average 3.2 times under reduced-till, compared with 3.9 times for conventional systems. For soybeans, reduced-till farmers made 4 tillage operations, compared with conventional farmers' 4.8.

With world oil supplies increasing faster than demand, crude oil prices have fallen precipitously since the beginning of this year. As a result, farmers can expect plentiful supplies of refined petroleum products. Currently, diesel prices are nearly 39 percent lower than last year. Farm energy expenditures are expected to be down $1 billion this year, because of lower oil prices and reduced crop plantings. In 1985, energy costs dropped 8 percent from a year earlier, to $8.6 billion.

In 1985, on-farm gasoline and diesel fuel use declined by 9.5 and 3.3 percent, respectively, largely due to reduced crop acreage and continued adoption of energy-saving technology. Diesel fuel use continues to gain relative to gasoline, as diesel-powered machinery replaces older gasoline-powered machinery.

Plant nutrient use in 1985/86 is projected to be about 21.6 million tons, down about 5 percent from a year earlier. In April, because of plentiful supplies and reduced use, fertilizer prices were down 8 percent from a year earlier. Intense competition in world fertilizer markets due to large supplies and flagging demand caused U.S. exports to fall and nitrogen imports to increase.

Pesticide use on the 10 major field crops in 1986 is projected at 475 million pounds, active ingredient (a.i.), down 6 percent from 1985. Planted acres for these crops declined from 281 million in 1985 to 268 million. Acres planted to corn, a major herbicide and insecticide user, were down the most at 6.6 million, or 8 percent from a year ago.

Average farm-level herbicide prices remained stable between 1985 and 1986 at $4.05 per pound (a.i.), but atrazine prices rose 5 percent. Insecticide prices are down 2 percent this year, compared with a 5.5-percent increase in 1985. Synthetic pyrethroid prices declined the most, 6 percent, to $51 per pound.

FARM MACHINERY

Demand

Despite record high net cash income and declining nominal interest rates in 1985, farmers' expenditures for new and used tractors and other farm machinery fell nearly 22 percent from 1984 to an estimated $5.68 billion. In percentage terms, this drop matched the 1982 record decline in farm machinery expenditures. In 1986, the forecast of relatively stable net cash farm income, a slightly higher debt/asset ratio, and higher real interest rates will likely depress farm machinery sales even further. Domestic demand for new and used farm machinery is expected to fall for the seventh consecutive year to between $4.8 and $5.1 billion. In nominal terms, farm machinery expenditures have not been that low since 1972.

Interest Rates

Nominal interest rates have declined since the early 1980's and could fall further this year as relatively low inflation and slow to moderate economic growth may influence an expansionary monetary policy. Before 1983, real agricultural interest rates were below the prime rate charged by banks (table 1). Subsequently, agricultural borrowers have paid rates well in excess of the prime, reflecting the greater risk associated with agricultural loans. Declining nominal interest rates and retirement of some farm debt should

Table 1--Trends in U.S. farm machinery capital expenditures and financial factors affecting demand for farm machinery

Item	1980	1981	1982	1983	1984	Preliminary 1985	Forecast 1986
				Billion dollars			
Capital expenditures:							
Tractors	3.68	3.74	2.88	2.75	2.53	1.91	1.58-1.68
Farm machinery	6.96	6.48	5.10	4.82	4.75	3.77	3.22-3.42
Total	10.64	10.22	7.98	7.57	7.28	5.68	4.8-5.1
Other costs:							
Tractor and machinery repairs	3.75	3.77	3.86	3.97	4.29	3.98	na
Tractor depreciation	3.62	4.09	4.05	3.87	3.54	3.23	3.07
Farm machinery depreciation	7.99	8.58	8.92	8.91	8.75	8.16	7.75
Factors affecting demand:							
Interest expenses	16.26	19.86	21.83	21.43	21.13	18.79	17.10
Total production expenses	129.39	136.13	136.92	135.63	139.50	135.00	124-128
Outstanding farm debt 1/	170.40	189.00	203.70	202.50	198.90	2/ 198.50	194-201
Farm real estate assets 1/	779.20	780.20	745.60	736.10	639.60	2/ 555.00	510-570
Farm nonreal estate assets 1/	224.00	225.00	232.20	220.40	216.50	2/ 215.00	190-235
Agricultural exports 3/	40.48	43.78	39.10	34.77	38.03	31.19	27.50
Net farm income	20.18	29.84	24.64	15.00	34.53	2/	30.50
26-30							
Net cash income	37.20	35.80	38.27	38.32	39.23	2/	44.50
42-46							
				Percent			
Real prime rate 4/	1.75	8.50	8.73	7.57	7.74	6.33	6.80
Real PCA interest rate 4/ 5/	-0.78	4.09	8.45	8.73	8.20	8.80	6/ 9.60
Nominal bank interest rate on farm machinery and equipment loans 7/	14.40	17.90	17.10	14.30	14.60	13.60	6/ 12.70
Debt-asset ratio 8/	17.00	18.80	20.80	21.20	23.20	2/ 26.00	24-28
Repair-to-capital expenditure ratio 9/	0.35	0.37	0.48	0.52	0.59	0.70	na

na = not available

1/ Calculated using nominal dollar balance sheet data, excluding farm households, for December 31 of each year. 2/ Midpoint of estimated range. 3/ Fiscal year. 4/ Deflated using the Consumer Price Index. 5/ Production Credit Association. 6/ First quarter 1986. 7/ Quarterly sample survey of commercial banks: Agricultural Finance Databook, Board of Governors of the Federal Reserve System. 8/ Outstanding farm debt (excluding farm households) divided by the sum of farm real and nonreal estate asset values. 9/ Tractor and machinery repair expenditures divided by total farm machinery capital expenditures.

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ERRATA

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Table 1, page 4 is corrected and reproduced below. Please cut out and tape it in place.

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save farmers over $1.5 billion in 1986 interest expenses compared with 1985. However, current real interest rates remain well above the real rates experienced prior to the 1980's. In fact, the modest CPI increase forecast for 1986 may result in the real prime rate rising from 6.3 percent in 1985 to 6.8 percent this year.

Due primarily to the precipitous fall in farm real estate values since 1981, many public and private agricultural lending institutions are undergoing reorganization. In some cases, interest rates charged to farmers carry added risk premiums; in other situations, lenders are attempting to reduce their exposure to the agricultural sector by diversifying their loan portfolios. In either case, lenders are likely to seek out or loan funds only to the most credit-worthy prospects, which may curtail the availability of capital to some producers.

Cropland Values

The value of farm real estate assets fell more than 13 percent or about $90 billion during 1985, and the value of nonreal estate assets declined about $2 billion, while total debt fell slightly. Cropland, which is the major asset in agriculture, fell in value an average of 12 percent per acre nationwide in 1985. Consequently, the debt/asset ratio on December 31, 1985, was estimated at 26, up from 23.2 one year earlier. The debt/asset ratio has increased over 50 percent since 1980, reflecting the extraordinary reduction in farm asset values. Lenders, in turn, are basing farm machinery loan decisions more on farmers' cash flow potential than on their equity position.

Farm Programs

Agricultural trade and agricultural policy also are key factors influencing the farm sector and are now more clearly linked than ever. U.S. agricultural exports are forecast to decline to $27.5 billion in fiscal 1986, down from $31 billion in 1985 and $38 billion in 1984. In an attempt to regain export markets, the 1985 Food Security Act significantly lowered loan rates for most major commodities, but at the same time protected farm incomes of program participants by freezing target prices during 1986 and 1987. Hence, while 1986 net cash farm income is expected to be only slightly below 1985 levels, the proportion of sector-wide income derived from Government programs will increase greatly.

Machinery Repairs and Used Machinery Purchases

In response to more austere times and increased caution about adding to fixed costs, farmers are repairing existing machinery and purchasing more used machinery. For example, the repair-capital expenditure ratio has doubled since 1980 as producers extended the life of their tractors and equipment. Furthermore, ample supplies of used machinery have encouraged farmers to purchase less new machinery. In the case of tractors, about 40 percent of all expenditures were for used vehicles in the early 1980's, but by 1985 the share had risen to nearly 55 percent. Because of depressed demand for new tractors, inventories relative to sales at record levels, and larger used tractor supplies, USDA's index of prices paid by farmers for tractors declined in 1985 for the first time since its introduction in 1965.

Used Tractors' Share of Total Tractor Outlays

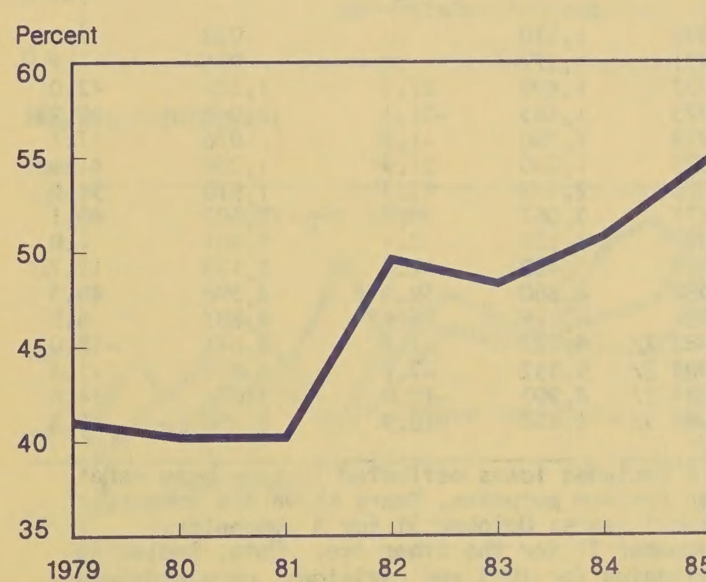


Table 2--Domestic farm machinery unit purchases

Machinery category	Annual average 1978-80	1981-83	1984	1985	Forecast 1986	Change 1985-86
			Units			Percent
Tractors:						
Two-wheel drive--						
40-99 hp	62,818	43,421	38,260	37,847	29,350	-22
Over-100 hp	59,543	33,528	24,505	17,700	18,640	+5
Four-wheel drive	10,276	7,188	3,975	2,912	1,960	-33
Grain and forage harvesting equipment:						
Self-propelled combines	29,834	18,594	11,437	8,411	5,825	-31
Corn heads	20,338	10,608	6,419	5,016	3,360	-33
Forage harvesters 1/	11,145	5,611	3,538	2,460	2,060	-16
Haying equipment:						
Balers 2/	17,501	10,528	8,315	7,038	5,600	-21
Mower conditioners	23,392	15,586	13,057	11,243	10,040	-11

1/ Shear bar type. 2/ Producing bales up to 200 pounds.

Source: Historical data are from the Farm and Industrial Equipment Institute (FIEI). Unit purchase projections are ERS forecasts. Inventory-to-purchase ratios presented in the farm machinery graphs were computed from data obtained from FIEI.

Table 3--Loan funds supplied by 6 major long-line farm machinery manufacturers for retail purchases of farm machinery and equipment 1/

Year	Loans outstanding end of year: Million dollars	Percent change	Loans made during year: Million dollars	Percent change
1970	1,170	--	928	--
1971	1,179	.8	936	.9
1972	1,499	27.1	1,329	42.0
1973	1,183	-21.1	1,065	-19.9
1974	1,160	-1.9	876	-17.7
1975	1,530	31.9	1,236	41.1
1976	2,192	43.3	1,915	54.9
1977	3,067	39.9	2,682	40.1
1978	3,131	2.1	2,661	-.8
1979	3,488	11.4	3,133	17.7
1980	4,860	39.3	4,396	40.3
1981	6,129	26.1	4,683	6.5
1982 2/	6,027	-1.7	3,841	-18.0
1983 2/	5,552	-7.9	3,555	-7.4
1984 2/	4,997	-10.0	3,036	-14.6
1985 3/	4,454	-10.9	2,450	-19.3

1/ Excludes loans estimated to have been made for nonfarm purposes. Years shown are company fiscal years: October 31 for 4 companies, December 31 for the other two. Data, including estimates for 1984 and revisions, were provided by the six companies. 2/ Revised. 3/ Estimated.

Unit Purchases

New farm machinery unit sales for 1985 paralleled the downward spiral of expenditures for farm machinery. Except for 40-99 horsepower (hp) two-wheel drive tractors, unit sales for all other categories of farm tractors, harvesting equipment, and haying equipment declined between 14 and 30 percent from 1984 (table 2). Unit sales of 40-99 hp two-wheel drive tractors, however, were only 1 percent less than a year earlier.

Loan activity by six major long-line farm machinery manufacturers reflect the dramatic decline in sales. Since 1981, annual loans made by the major manufacturers have fallen nearly 48 percent, from $4.7 billion to $2.5 billion (table 3). Loans outstanding at the end of the fiscal year also have declined, but these figures do not include loan discounting or sales of credit instruments to other financial institutions.

Forecasts for 1986 unit sales indicate further weakening of demand for most major farm machinery items (see special articles on

forecasting methodology). However, unit sales of new over–100 hp two–wheel drive tractors are forecast to increase about 5 percent this year (table 2). This is due primarily to a sales incentive program that boosted sales of over–100 hp two–wheel drive tractors in June 1986. But the other tractor categories are expected to continue their precipitous decline that began in the early 1980's. The 40–99 hp unit sales category is expected to decline by 22 percent, while sales of four–wheel drive tractors are forecast to fall nearly 33 percent from 1985. Harvesting equipment unit sales also are projected to decline, with self–propelled combines and corn heads down more than 30 percent, and forage harvesters down 16 percent. Partly because of declining cattle and dairy herd inventories, haying equipment sales also are projected to fall, but not as much as other equipment categories. Balers are expected to drop nearly 21 percent and mower conditioners could be down 11 percent.

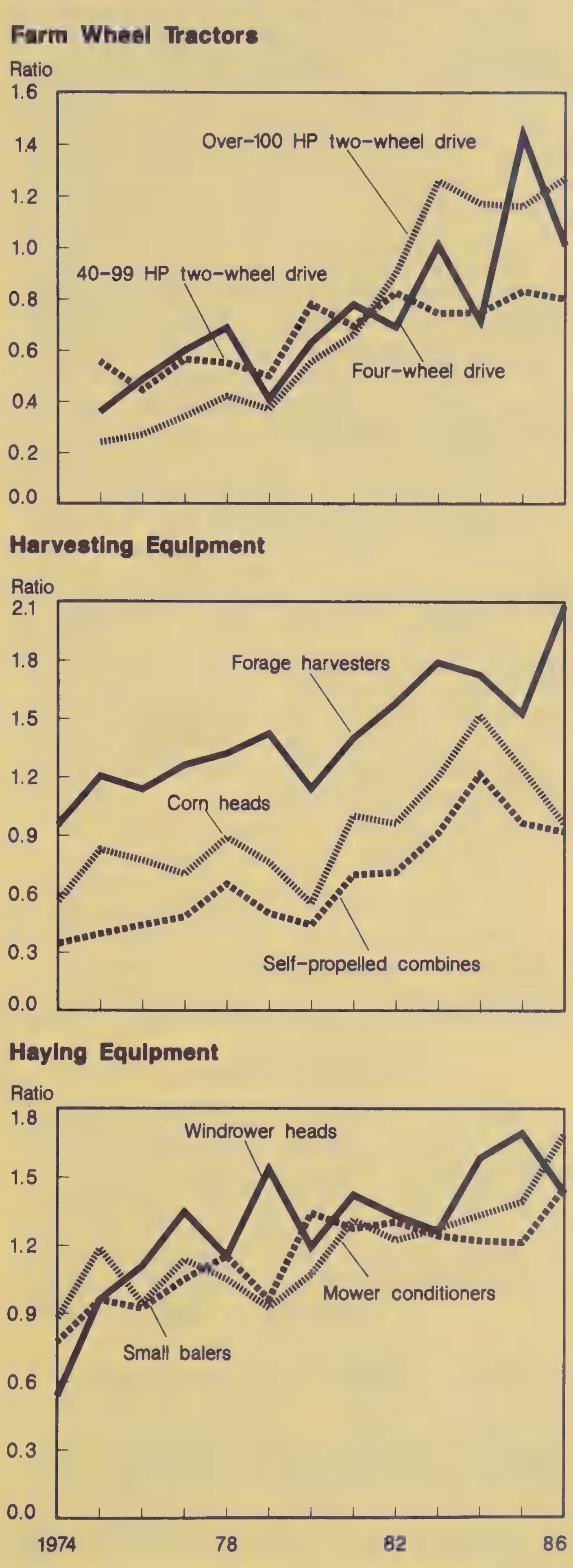
Supplies

The inventory–to–purchase ratio (IPR) is a widely used measure that assists manufacturers in relating inventories to unit sales. It measures the inventory of an item in a given month relative to its respective sales during the previous 12–months. An IPR value of 1.25 indicates there currently is a 15–month inventory in the market.

May IPR's for the major farm machinery items were mixed and indicate further production cuts are needed to remedy an oversupply situation. A common factor influencing the May IPR's for several of the major equipment categories has been the steady decline in unit sales. This decline continues to offset manufacturers' progress in reducing the absolute levels of inventories. Consequently, manufacturers have announced their intentions to extend the normal to 3– to 4–week summer plant closings by 1 week this year.

For example, as of May 1986, over–100 hp two–wheel drive tractor supplies were down 29 percent to 18,400 units from 25,900 in 1985. Nevertheless, the May IPR reveals that supplies relative to sales rose to a 15–month level compared with a 13.9–month supply last year. Similarly, May inventories for forage

May Inventory-to-Purchase Ratios



harvesters, small balers, and mower conditioners declined in absolute terms, but increased relative to sales. Forage harvester inventories rose 36 percent to a 25-month supply, while small baler inventories increased 20 percent over last year to a 17.4-month supply. Mower conditioner supplies rose from a 16.7-month supply in 1985 to 19.7 months this May.

Despite these setbacks, domestic farm machinery manufacturers have reduced both the absolute and relative inventory levels for 40-99 hp two-wheel drive and four-wheel drive tractors and selected harvesting and haying equipment. May inventories of 40-99 hp two-wheel drive tractors were roughly 7 percent below the 1985 level of 36,900. This reduction was accompanied by a comparable drop in the IPR. The May IPR for 40-99 hp two-wheel drive tractors shows a 4-percent decline in inventories from 10 months in 1985 to 9.6 months in 1986. The May 1986 IPR for four-wheel drive tractors was 11.9 months, a sharp drop of 31 percent from May 1985 when it stood at 17.3 months. Self-propelled combine inventories on an IPR basis fell from an 11.6-month to an 11.2-month supply in May 1986, while the windrower head inventory dropped to a 17.3-month supply. Corn head inventories declined 23 percent in May 1986 to an 11.5-month supply.

The elimination of production capacity, curtailed production schedules, and temporary plant shutdowns are three of the more important measures U.S. manufacturers have employed to draw down excessive inventories.

Foreign Trade

The U.S. farm machinery trade situation deteriorated to an unprecedented level in first-quarter 1986 as a $41-million trade deficit was registered (table 4). The value of exported assembled farm machinery and component parts fell 4 percent to $407 million from a year earlier. Concurrently, the value of imported assembled farm machinery and component parts rose 7 percent to $448 million. The United States' unprecedented status as a net importer of farm machinery evolved in part from domestic manufacturers' decisions to specialize in the production of large tractors (over-100 hp) and to relocate under-100 hp tractor production capacity abroad, specifically Western Europe and Japan.

Table 4--Farm machinery trade situation 1/

Trade, area	January-March 1985	January-March 1986	Change 1985-86
	Million dollars		Percent
Exports to:			
Africa	18.5	19.4	5
Australia	35.0	13.7	-61
Canada	181.2	192.4	6
Central America 2/	7.7	10.8	40
Eastern Europe	8.0	3.4	-58
Far East	12.0	11.4	-5
Mexico	49.1	26.3	-46
Middle East	5.0	3.9	-22
Near East	3.8	2.4	-37
Oceania	0.7	0.8	14
Saudi Arabia	23.1	11.4	-51
South America	18.5	25.1	36
Western Europe	60.2	86.0	43
Total	422.8	407.0	-4
Imports from:			
Africa	0.3	0.4	33
Canada	108.6	76.1	-30
Central America 2/	0.4	1.5	275
Eastern Europe	5.5	5.4	-2
Far East 3/	3.5	3.5	—
Italy	32.1	30.5	-5
Japan	95.7	131.6	38
Middle East	2.4	2.9	21
Near East	0.2	0.03	-85
Oceania	4.7	3.1	-34
South America	4.7	3.5	-26
United Kingdom	63.3	61.9	-2
West Germany	57.4	78.5	37
Western Europe 4/	41.0	49.2	20
Total	419.8	448.1	7
Trade balance 5/	3.0	-41.1	-1370

1/ Includes finished machinery items, nonassembled machinery, and parts. 2/ Includes Caribbean countries and excludes Mexico. 3/ Excludes Japan. 4/ Excludes Italy, the United Kingdom, and West Germany. 5/ Trade balance is slightly overstated due to rounding of country export and import totals.

Source: U.S. Department of Commerce. Trade Development, Office of Special Industrial Machinery.

The impetus for these decisions took root in the 1970's, when the U.S. agricultural sector flourished under expanding agricultural commodity exports, high crop prices, and rising cropland values and farm income. As a result, farmers expanded their production capacity, and in turn increased their demand for higher-powered farm machinery. The demand for high-powered farm machinery also grew in Canada as its agricultural sector prospered under similar economic conditions. Over the same period, domestic manufacturers

began a systematic overseas relocation of under-100 hp (small and mid-size) tractor production capacity. This strategy allowed U.S. manufacturers to circumvent foreign tariff and nontariff barriers and compete more effectively in overseas markets. By the end of the 1970's, the domestic industry had become very specialized, totally oriented to the production of larger farm machinery items. Such specialization has had the effect of limiting the exports of U.S.-made farm machinery, primarily to Canada and Australia with similar capital-intensive agricultural practices.

As a result, fluctuations in the total value of farm machinery exports and the magnitude of the U.S. machinery trade balance historically have hinged on trade with Canada and Australia. Through first-quarter 1986, the combined value of U.S. farm machinery exported to Canada and Australia represented slightly over 50 percent of the total value. The value of exports to Canada ($192.4 million) during first-quarter 1986 was up 6 percent from last year. A respective 4- and 19-percent increase in the value of exports of harvesting machinery and parts and wheel tractors and parts were the driving forces behind the upsurge. Harvesting machinery and wheel tractor parts accounted for $131 million, or 68 percent of the total value of farm machinery exported to Canada. Excluding the $35 million in wheel tractor parts exported to Canada, large tractor exports accounted for 95 percent of all assembled tractors shipped to Canada.

Significant declines in the value of farm machinery exported to Australia, Mexico, and Saudi Arabia during first-quarter 1986 offset the increase in exports to Canada. Poor financial conditions in the Australian agricultural sector, including high interest rates and low crop prices, are the chief reasons behind the 61-percent decline in the value of machinery exports to Australia. Also, the mature nature of the Australian farm sector continues to exert a dampening effect on the flow of exports to Australia. The value of harvesting machinery and parts and wheel tractors and parts exported to Australia was down about 83 and 43 percent, respectively, from a year ago.

With the absence of any appreciable growth potential in the Canadian and Australian markets, trading partners such as Western Europe, Mexico, and Saudi Arabia have become very important to the maintenance of a relatively stable U.S. farm machinery export base. These "swing partners" usually offer domestic manufacturers short-run export trade increases, which can make up for decreased exports to either Canada or Australia. Normally, trade with a "swing partner" involves specialized farm equipment or component parts. For example, the value of exports to Western Europe was up roughly 43 percent in first-quarter 1985 from a year earlier. Of the total, $43 million, or 50 percent, was for wheel tractor parts, undoubtedly destined for foreign-based U.S. subsidiaries. However, with tractor demand stable in Western Europe and declining in the United States, this export gain could be short-lived.

Likewise, for several years Saudi Arabia's agricultural development program had a positive effect on the total value of U.S. farm machinery exports. But as Saudi Arabia's agricultural development program nears fruition, exports of irrigation equipment, which accounted for 62 percent of the value of U.S. farm machinery exports to Saudi Arabia, have plunged 33 percent. The total value of farm machinery exports to Saudi Arabia declined 51 percent, or $11.7 million, from first-quarter 1985.

Mexico is another example of a trading partner that only last year provided an added boost to the value of U.S. farm machinery exports. Currently, however, Mexico is faced with recurring foreign debt problems due largely to the fall in world crude oil prices. Consequently, first-quarter farm machinery exports to Mexico declined 46 percent from a year ago. Increased exports to Africa, South America, and Central America during first-quarter 1986 could signal new "swing" markets that might offset decreased trade to traditional export markets.

Gradually, farm machinery imports have become increasingly important to the domestic farm machinery industry as U.S. manufacturers relocated their under-100 hp tractor production capacity abroad. Specifically, production of under-40 hp tractors was transferred to Japan, where

domestic manufacturers contract with Japanese firms to produce these units. Production of 40–99 hp wheel tractors has been transferred to Western Europe, largely via U.S. subsidiaries. In recent years, the strength of the U.S. dollar on the world market has hastened this relocation. In addition, Japanese and European firms have autonomously begun producing mid-size tractors to market in this country to supplement their market base. Imports of small- and mid-size tractors increased in recent years and through first-quarter 1986, because of a sharp increase in the demand for small tractors for nonagricultural uses and farmers' preference for smaller, more affordable tractors.

Imports of wheel tractors and parts in the first quarter were valued at $290 million, or 64 percent of all first-quarter imports. The 40–79 hp wheel tractor category was the single most important tractor category imported. About 13,875 units, worth $93.8 million and representing about one-third of the total value of wheel tractors and parts, were imported during first-quarter 1986. Despite a decline in domestic unit sales of 40–99 hp tractors, the 43-percent increase in the value of 40–79 hp wheel tractor imports indicates that farmers are buying tractors with less horsepower. West Germany, the United Kingdom, and Japan accounted for 95 percent of these imported tractors.

The United States imports more farm machinery on a value basis from Japan than any other country, a position formerly held by Canada, which now ranks third behind Japan and West Germany. Roughly $132 million in farm machinery were imported from Japan during the first quarter, up 38 percent from a year earlier. Of this, $118 million were wheel tractors and parts. West Germany led all Western European countries, shipping $78.5 million in farm equipment to the United States, up 37 percent from first-quarter 1985.

CHANGING SEASONAL PATTERNS IN DOMESTIC FARM MACHINERY UNIT SALES

by

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Abstract: U.S. farmers now buy proportionately less new farm machinery during peak purchasing periods and more during off-peak periods, compared with seasonal patterns during the 1970's. Also, based on seasonal factor forecasts, unit sales of most major farm machinery categories are projected to continue declining in 1986, sustaining the weakening sales trend that began in 1981.

Keywords: U.S. farm machinery unit sales, seasonal patterns, and annual sales forecasts.

Introduction

The downturn in the U.S. farm economy during the 1980's not only caused farmers to purchase less new farm machinery, but also appears to have modified the timing of new machinery purchases relative to the 1970's. Presented in this report is an overview of the seasonality associated with domestic sales of farm wheel tractors, grain and forage harvesting equipment, and haying equipment. Included is a discussion of changes in seasonal farm machinery purchasing patterns, some possible reasons for the changes, and a demonstration of how one can utilize out-of-sample forecasts of monthly seasonal

factors to project current-year unit sales or to monitor independent annual sales projections as monthly unit sales data become available.

Seasonal Adjustment Procedure

Seasonal factors were estimated for nine major farm machinery categories using monthly unit sales data obtained from the Farm and Industrial Equipment Institute. Sales data for farm wheel tractors (1973–86) and grain and forage harvesting and haying equipment (1972–86) were seasonally adjusted using a statistical procedure, X–11–ARIMA (an Autoregressive Integrated Moving Average technique), developed by Statistics Canada and used by the U.S. Department of Commerce (1).

X–11–ARIMA is a moving average technique similar to the Box and Jenkins procedure, in which it is assumed that monthly or quarterly fluctuations in a time series are stochastic, or randomly drawn from a probability distribution, and can be broken into several identifiable components. These include seasonal movements that are short term in nature and are measurable on a year-to-year basis, cyclical patterns that evoke either long-term or business trends, and irregular variation which represents either unexplainable or random phenomena.

Unlike structural or econometric equations, which are based on the assumption that fluctuations or variations over time are a function of one or more explanatory variables plus an error term, moving average or univariate techniques like X–11–ARIMA identify and break down time series fluctuations as either seasonal, trend, or irregular patterns by solely analyzing previous values and random disturbances in the series.

X–11–ARIMA also is capable of extrapolating a year's worth of monthly seasonal factors with a greater degree of statistical reliability than earlier moving average techniques because the ARIMA model minimizes the mean square error of seasonal estimates. After undergoing an iterative adjustment process, X–11–ARIMA estimates a historical, seasonally adjusted monthly data series, a set of historical monthly seasonal factors, measures of variation due to seasonal, cyclical, and irregular considerations, and a set of diagnostic statistics to determine the statistical reliability of the final seasonal adjustments. Also, monthly seasonal factors are forecast for the year ahead. Out-of-sample seasonal factor forecasts can be used to more accurately assess current data trends and to make current-year projections for the adjusted time series.

Seasonal factor estimates can be revised monthly as data become available. The statistical reliability of seasonal adjustments made with X–11–ARIMA depends not on the length of a time series, but on the relative degree of identifiable, consistent seasonality in a time series.

Seasonal Purchasing Patterns Tempered

Estimated seasonal factors for sales of the major farm machinery categories reveal a consistent change in the timing of farm machinery purchases in the past few years compared with patterns established during the 1970's. Historically, and to a diminishing extent since 1982, farmers have bought machinery just before or at planting time and during harvest. For instance, most farm wheel tractors are purchased from March through May, when extensive field preparation and planting of most major field crops get underway, and in October when harvesting of most field crops is in full swing and winter wheat is being planted. Likewise, grain and forage harvesting equipment sales hit a seasonal high in September and October, while haying equipment sales are greatest from June through August.

Since 1982, however, seasonal patterns in farm machinery sales have weakened, reflecting relatively both lower machinery sales during peak purchasing months and higher sales in off-peak months. Comparisons of seasonal factors are made for three time periods—1972 or 1973 to 1977, when gross capital expenditures for farm machinery were increasing; 1978 to 1981, when capital expenditures were record high; and 1982 to 1985, when expenditures fell sharply. For forecasting purposes, seasonal factors were estimated for 1986.

Seasonal factors estimated by X–11–ARIMA for a given farm machinery item represent the percent of sales each month relative to the average monthly sales for the

Table 5--Seasonal factors for domestic farm machinery unit sales 1/

Item	Period	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
							Percent						
WHEEL TRACTORS													
40-99 horse- power 2wd tractors	1973-77 avg	82	74	128	144	117	117	84	75	101	134	60	82
	1978-81 avg	86	71	114	148	109	125	98	76	96	133	70	77
	1982-85 avg	88	73	107	127	114	139	100	80	94	119	78	81
	1986 proj	88	73	109	123	114	146	101	79	87	118	82	81
Over-100 horsepower 2wd tractors	1973-77 avg	95	76	123	145	99	88	64	68	95	163	74	109
	1978-81 avg	99	75	114	152	95	88	68	69	94	164	87	100
	1982-85 avg	102	73	101	136	93	96	79	70	95	158	103	93
	1986 proj	103	72	99	135	94	99	80	69	95	155	106	91
4wd tractors	1973-77 avg	76	63	102	148	105	90	73	76	101	179	77	109
	1978-81 avg	82	66	105	140	101	92	72	73	100	167	94	108
	1982-85 avg	90	71	105	120	103	108	71	70	101	134	99	130
	1986 proj	90	71	105	116	108	116	68	67	99	126	97	138
HARVESTING EQUIPMENT													
Self-propelled combines	1972-77 avg	47	30	45	54	44	107	116	123	212	277	66	77
	1978-81 avg	64	36	43	50	44	85	123	112	184	277	92	85
	1982-85 avg	100	44	39	45	47	67	105	112	158	234	132	115
	1986 proj	110	45	36	46	47	63	99	115	155	225	141	121
Corn heads	1972-77 avg	46	25	29	31	22	50	70	89	268	377	106	86
	1978-81 avg	59	31	33	36	28	45	80	94	231	352	114	87
	1982-85 avg	104	45	35	34	34	42	62	88	197	299	144	109
	1986 proj	118	49	35	34	35	41	55	89	193	289	150	115
Forage harvesters	1972-77 avg	32	23	31	33	45	120	121	135	251	257	95	52
	1978-81 avg	35	24	37	39	56	132	131	130	236	228	103	45
	1982-85 avg	40	24	41	45	64	139	148	126	211	213	99	49
	1986 proj	41	24	42	47	64	140	151	122	210	212	97	51
HAYING EQUIPMENT													
Small balers 2/	1972-77 avg	34	27	45	50	96	280	257	169	112	80	23	27
	1978-81 avg	41	29	50	56	100	262	269	147	108	81	28	29
	1982-85 avg	44	29	63	66	101	249	292	136	90	63	36	29
	1986 proj	45	29	69	71	101	251	290	134	87	58	38	29
Mower conditioners	1972-77 avg	36	29	54	49	105	307	234	147	109	73	26	32
	1978-81 avg	39	29	63	58	118	315	206	126	107	77	29	35
	1982-85 avg	43	32	70	66	124	295	227	110	95	63	35	36
	1986 proj	49	33	71	67	127	295	233	104	89	63	35	35
Windrower heads	1972-77 avg	33	26	44	51	80	228	267	217	140	66	19	28
	1978-81 avg	33	29	61	57	88	220	242	190	137	78	28	36
	1982-85 avg	39	31	75	64	92	203	240	172	115	87	37	44
	1986 proj	41	32	78	67	97	202	238	167	109	86	40	45

1/ Computed for sales data through 1985. 2/ Units producing bales up to 200 pounds.

year. For example, average annual seasonal factors for 40-99 horsepower (hp) two-wheel drive tractors show that sales during 1973-77 hit a seasonal low in November when they were about 60 percent of the 12-month average, and a seasonal high in April when they were 144 percent of the 12-month average (table 5).

For farm wheel tractors, 1982-85 annual average seasonal factors differed significantly from 1973-77 averages. The March or April seasonal factors for all three tractor categories fell, as did the September and October factors for 40-99 hp two-wheel drive tractors, and the October value for four-wheel drive tractors. On the other hand, seasonal

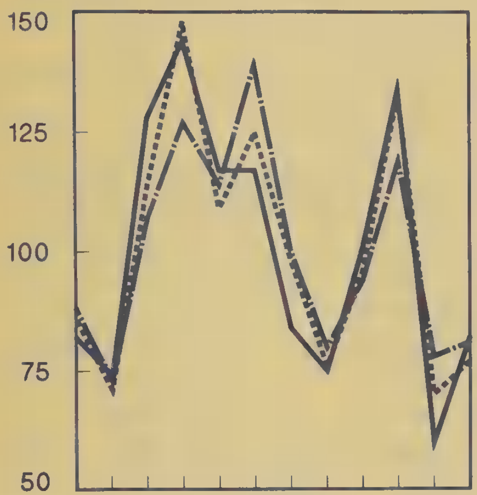
Seasonal Unit Sales Patterns

—— 1973-77 average ····· 1978-81 average —·— 1982-85 average

Tractors

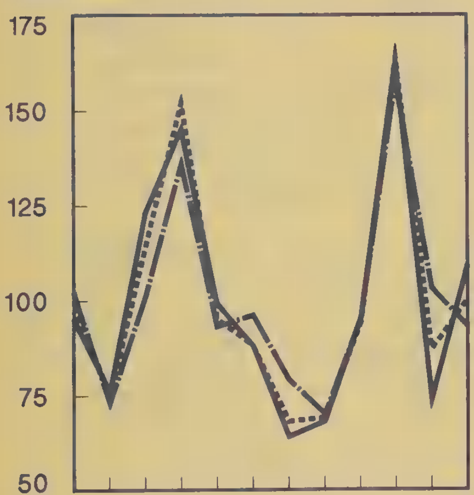
40-99 HP Two-Wheel Drive

Percent[2]



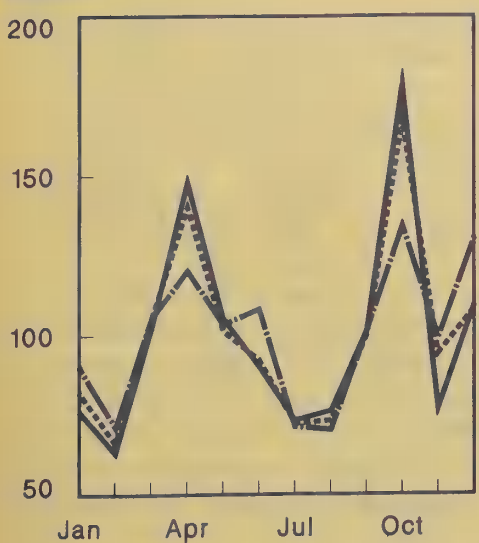
Over-100 HP Two-Wheel Drive

Percent[2]



Four-Wheel Drive

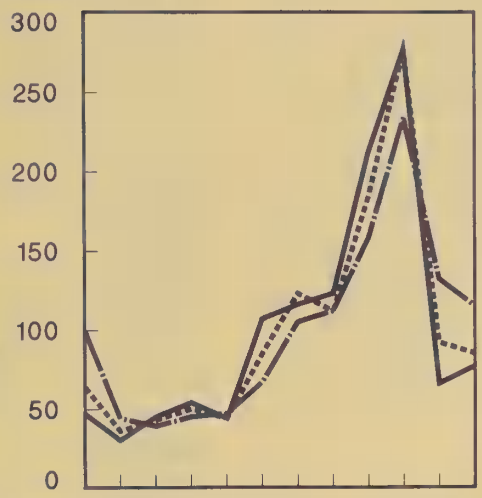
Percent[2]



Harvesting Equipment

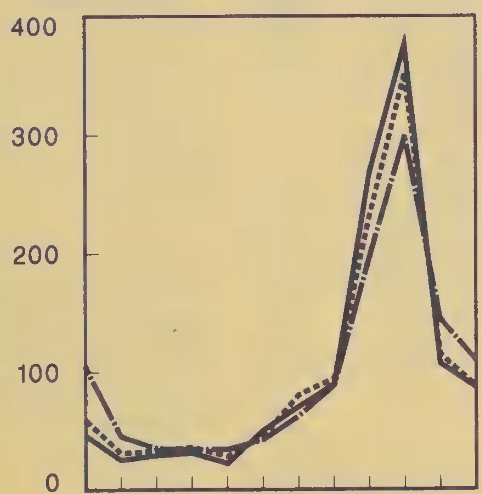
Self-Propelled Combines

Percent[2]



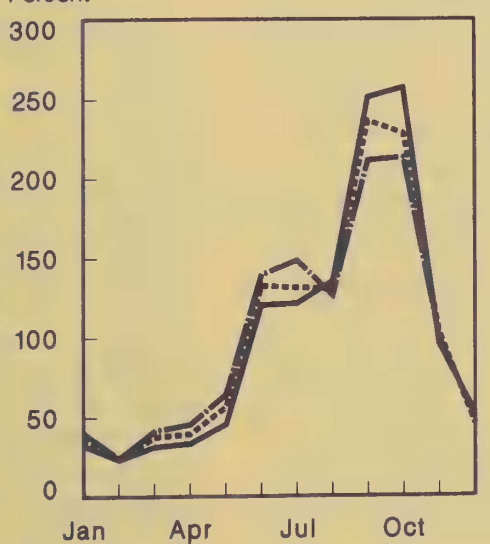
Corn Heads

Percent[2]



Forage Harvesters

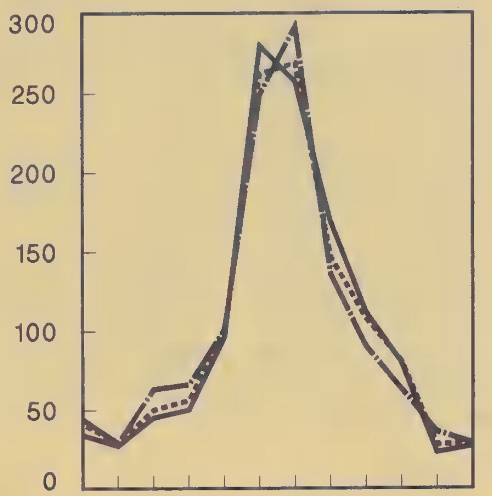
Percent[2]



Haying Equipment

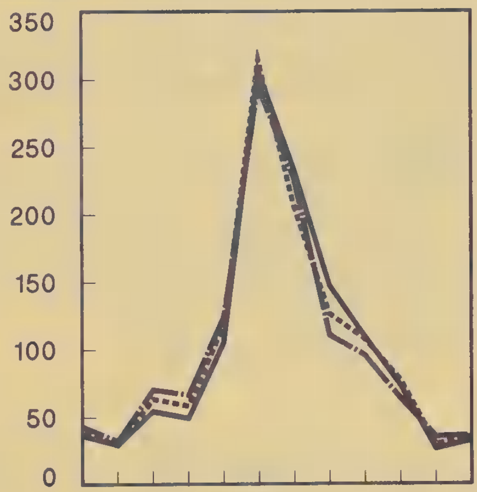
Small Balers[1]

Percent[2]



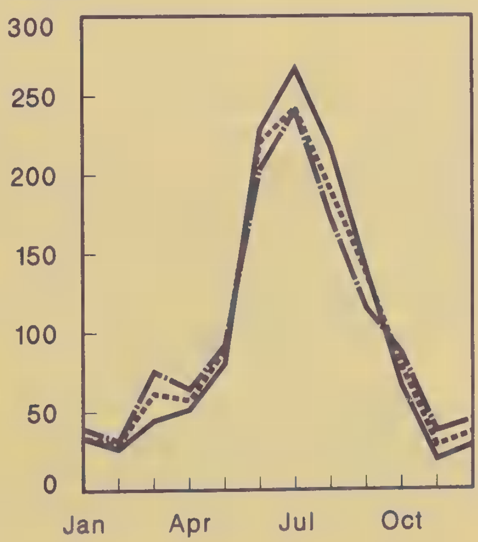
Mower Conditioners

Percent[2]



Windrower Heads

Percent[2]



1/ Units producing bales up to 200 pounds. 2/ Percent of 12-month average.

factors generally increased sharply in off-peak months, particularly in months (June and November) just following historical peak sales periods.

Also, compared with 1972-77 averages for the three grain and forage harvesting equipment categories, 1982-85 September and October seasonal factors declined 16 to 26 percent. There were, however, differences in off-peak month increases in seasonal factors for harvesting equipment compared to farm wheel tractors. For self-propelled combines and corn heads, seasonal factors rose sharply from November through February, following the October peak. And, for forage harvesters, seasonal factors jumped markedly in April through July, prior to the peak sales period in early fall.

Changes in seasonal factors for haying equipment, though not as large, also were observed. In general, 1982-85 seasonal factors for small balers, mower conditioners, and windrower heads were down sharply in July through October and up significantly in most off-peak months, particularly November, January, March, and April. There was an exception to the current overall trend in seasonal patterns---for small balers, the 1982-85 average seasonal factor in the peak month of July was higher than averages in the earlier comparison periods.

Results of F tests to determine the presence of seasonality in the data series for sales of the major farm machinery items all were significant at the 1-percent confidence interval. Also, the diagnostic statistics measuring the degree and relative nature of seasonal and irregular components all were in the acceptable range for all categories except over-100 hp two-wheel drive tractors, which had marginally unacceptable diagnostics. Comparison of the seasonal factors suggests that though seasonal patterns for domestic farm machinery unit sales are statistically significant, they have been tempered somewhat in recent years.

Though it has not been empirically determined, it appears that changing seasonal purchasing patterns primarily reflect the dramatic downturn in demand for farm machinery and the response of the domestic farm machinery industry to new market realities. Due to the weakening U.S. farm economy over the past several years, sales of all major farm machinery items fell sharply and market inventories rose to record highs. As a result, farm machinery manufacturers and dealers have offered a wide array of attractive sales incentives, especially during the past 3 years, to encourage farmers to purchase new machinery. Incentives may have been more attractive during off-peak periods, particularly in months just following peak sales periods. If this is the case, it suggests that as long as domestic demand for farm machinery stays depressed, seasonal fluctuations in sales will not be as great as levels observed in the 1970's, as the domestic farm machinery industry adjusts to lagging sales by adopting marketing, production, and inventory strategies that are more conducive to current market conditions.

Also, tax considerations, based on shortened depreciation schedules established in the 1981 tax bill, may have induced additional late-season sales of farm machinery, particularly big-ticket items like large two-wheel drive and four-wheel drive tractors and self-propelled combines.

Out-of-sample seasonal factor forecasts projected by X-11-ARIMA for 1986 farm machinery unit sales, influenced primarily by sales fluctuations in the most recent years, suggest that the flattening out of seasonal patterns over the year will continue for the major farm machinery categories.

Using Seasonal Factors To Forecast Annual Sales

Various means are used by economists and market analysts to forecast sales. Use of out-of-sample monthly seasonal factor forecasts allows one to more objectively assess monthly sales data as they become available, as well as to update current-year monthly sales forecasts. How would one have fared during the past 3 years using out-of-sample seasonal factor forecasts to project current-year farm machinery sales? To find out, a comparison is made between actual and projected farm machinery unit sales during 1983-85. Unit sales projections for 1986, based on current-year out-of-sample seasonal factor forecasts, also are presented.

Table 6--Actual and projected domestic farm machinery unit sales

Year, item	Actual sales	Projected annual sales based on the average of monthly seasonal factor forecasts through			Difference between actual and projected sales 1/		
		March	June	Sept	March	June	Sept
		Units			Percent		
1983							
40-99 hp 2wd tractors	38,137	37,922	38,834	38,064	-0.6	1.8	-0.2
Over-100 hp 2wd tractors	28,115	25,370	29,267	27,879	-9.8	4.1	-0.8
4wd tractors	5,098	4,280	4,695	4,904	-16.0	-7.9	-3.8
S-p combines	12,746	22,859	16,592	14,367	79.3	30.2	12.7
Corn heads	6,830	14,307	10,753	8,567	109.5	57.4	25.4
Forage harvesters	4,086	5,805	5,295	4,221	42.1	29.6	3.3
Small balers 2/	9,034	12,716	11,371	13,719	40.8	25.9	51.9
Mower conditioners	14,257	16,582	15,861	15,028	16.3	11.3	5.4
Windrower heads	2,887	3,810	3,669	3,227	32.0	27.1	11.8
1984							
40-99 hp 2wd tractors	38,260	42,708	41,081	38,274	11.6	7.4	0.0
Over-100 hp 2wd tractors	24,505	25,499	27,374	24,810	4.1	11.7	1.2
4wd tractors	3,975	5,366	5,318	4,397	35.0	33.8	10.6
S-p combines	11,437	13,135	12,000	11,174	14.8	4.9	-2.3
Corn heads	6,419	8,344	7,565	6,820	30.0	17.9	6.3
Forage harvesters	3,538	4,297	4,009	3,723	21.4	13.3	5.2
Small balers 2/	8,315	10,722	9,742	9,185	28.9	17.2	10.5
Mower conditioners	13,057	17,752	15,382	14,377	36.0	17.8	10.1
Windrower heads	2,307	3,330	2,849	2,571	44.3	23.5	11.4
1985							
40-99 hp 2wd tractors	37,847	34,129	39,239	37,404	-9.8	3.7	-1.2
Over-100 hp 2wd tractors	17,700	20,719	20,667	19,357	17.1	16.8	9.4
4wd tractors	2,912	2,559	2,740	2,677	-12.1	-5.9	-8.1
S-p combines	8,411	6,534	8,121	8,154	-22.3	-3.5	-3.1
Corn heads	5,016	3,607	4,407	4,847	-28.1	-12.1	-3.4
Forage harvesters	2,460	3,411	3,208	2,850	38.7	30.4	15.9
Small balers 2/	7,038	7,587	8,294	7,528	7.8	17.8	7.0
Mower conditioners	11,243	11,389	12,402	11,621	1.3	10.3	3.4
Windrower heads	1,962	2,167	2,285	2,041	10.5	16.5	4.0
1986 3/							
40-99 hp 2wd tractors	--	28,220	29,352	--	-25.4	-22.4	--
Over-100 hp 2wd tractors	--	16,620	18,642	--	-6.1	5.3	--
4wd tractors	--	2,460	1,960	--	-15.5	-32.7	--
S-p combines	--	6,327	5,823	--	-24.8	-30.8	--
Corn heads	--	3,615	3,356	--	-27.9	-33.1	--
Forage harvesters	--	2,005	2,059	--	-18.5	-16.3	--
Small balers 2/	--	5,869	5,592	--	-16.6	-20.6	--
Mower conditioners	--	10,077	10,039	--	-10.4	-10.7	--
Windrower heads	--	2,324	1,913	--	18.5	-2.5	--

-- = Not available.

1/ For 1986, percentage differences are from 1985 actual sales. 2/ Units producing bales up to 200 pounds. 3/ June projections are based on actual January-May sales and preliminary June sales, except for corn head and windrower head projections, which are based on January-May actual sales.

It must be pointed out that sales projections primarily made from out-of-sample seasonal factor forecasts are predicated on recently observed seasonal and trend fluctuations and, consequently, are not as reliable if current-year sales are markedly affected by an abrupt, significant change in market conditions. For example, a decision by major manufacturers to offer below-market finance rates or other substantial sales incentives could generate sales of farm machinery that otherwise would not be made, thus changing the market environment from what had previously transpired and diminishing the reliability of seasonal factors for projecting current-year machinery sales.

Comparison of actual and forecast farm machinery sales for 1983-85 shows that, as one would expect, the accuracy of annual sales projections derived from seasonal factor forecasts improves over the course of the year, especially for harvesting and haying equipment. In general, sales forecasts based on averages of monthly seasonal factor projections, though substantially different for some categories early in the year, are within 5 percent of actual annual sales for more than one-half of the machinery categories through September (table 6).

Furthermore, the accuracy of annual sales projections made through March, June, and September tended to increase from 1983 through 1985, as the impact of sharply declining unit sales, which began in 1981, influenced seasonal factor forecasts for 1985 to a greater degree than for either 1983 or 1984. Also, the sharp drop in farm machinery sales, especially grain harvesting equipment sales, during 1983 in response to the PIK program is a prime example of an abrupt market-influencing event that seasonal factor forecasts are incapable of anticipating. Again, this points out the inability of seasonal factor forecasts to account for significant nonseasonal events. Consequently, the reliability of projected seasonal factors is greater in a stable market environment, and in this example increases from 1983 to 1985.

Farm machinery sales projections for 1986, based on the average of the January-June out-of-sample monthly seasonal factor forecasts, indicate that sales of 40-99 hp two-wheel drive tractors will fall about 22 percent from a year ago to 29,350 units, over-100 hp two-wheel drive sales will rise 5 percent to 18,650 units, and four-wheel drive sales will decline 33 percent to 1,960 units. Grain harvesting equipment sales are expected to drop by about one-third, and forage harvester sales are anticipated to fall 16 percent. Haying equipment sales are projected to decline--21 percent for small balers, 11 percent for mower conditioners, and 3 percent for windrower heads. These sales forecasts, based on recent seasonal patterns, generally support projections made at the beginning of 1986 using econometric equations, which suggest that domestic demand for new farm machinery will continue to weaken this year (2).

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CHOOSING A FORECASTING SYSTEM: A FARM TRACTOR SALES EXAMPLE

by

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Abstract: Many farm machinery market analysts have reported observing patterns in unit tractor sales. If such patterns exist, accurate sales forecasts can easily be made. This research shows that some of the monthly variation can be explained by embedded time patterns, but the pattern is neither simple nor obvious by examination of only the raw data. We develop three different forecasting models to incorporate the hypothesized inertia in the farm machinery market. Problems relating to measuring forecast accuracy and choosing appropriate forecasting tools are discussed. The best models are used to forecast sales for 1986.

Keywords: Tractor sales, forecasting, time-series analysis, and seasonality.

Introduction

All businesses forecast the future. Planning decisions, either implicitly or explicitly, embody guesses about future product demand. Input purchase decisions balance assumed needs against assumed price levels and the timing of price changes. This paper shows that the accuracy of different forecasts can be evaluated, testing the validity of the wisdom each incorporates. Forecasts of farm machinery unit sales are used as an example.

Farm input manufacturers need to have some idea of future demand for their products so they can avoid both unnecessary inventory expenses and lost opportunities to meet demand. U.S. farm tractor sales have declined sharply in recent years. Sales of four-wheel drive tractors fell 27 percent from 1984 to 1985, 22 percent from 1983 to 1984, and 25 percent from 1982 to 1983. Sales of two-wheel drive tractors also have declined every year since 1980, although the percentage changes have been more variable. Inventory-to-purchase ratios for many types of farm machinery have increased sharply in recent years, pointing out the need for a reliable sales forecasting model (5,7).

Forecasts are always in excess supply, but accurate forecasts are always scarce. The farm machinery market planner's problem of selecting among forecasts is difficult not only because there are many choices, but because forecast methods are so different. Analysts may make forecasts using their own beliefs about the market or they may make forecasts in a mechanical way, using a mathematical or statistical model. The latter methods range from extremely simple to highly complex. Forecast providers often fail to provide much information about their methods. In those cases, the forecasting mechanism is a "black box" so far as the forecast consumer is concerned. Thus the forecast consumer, choosing among competing forecasts and forecasting techniques, has the unusual problem of never being quite sure what is being purchased.

Several industry analysts have noted that monthly unit sales of many types of farm machinery have displayed strong seasonal patterns (6,8). If these seasonal patterns are indeed rigid, accurate sales forecasts could be produced by knowing little more than the recent past. This article examines that hypothesis and shows that only a few of the commonly held beliefs concerning cycles in farm machinery sales are useful for forecasting purposes. In the limited cases where that information can be applied to reach "acceptable" forecast error levels, application requires a complex procedure to filter patterns from random variation.

This article presents and compares the results of three alternative forecasting techniques for three types of farm tractors: 40-99 horsepower (hp) two-wheel drive tractors, over-100 hp two-wheel drive tractors, and four-wheel drive tractors. Forecasting techniques considered include a 5-year moving average, a random walk, and an autoregressive integrated moving average (ARIMA) model. The first is an ad hoc technique, while the other two are time-series, time-domain models sharing many features with ad hoc models. Monthly historical data used in this analysis are from the Farm and Industrial Equipment Institute.

Forecasting Tools

Economic theory is the basis for a major class of forecasting models. Typically, economic models rely on assumptions about rational, calculating behavior. Movements in forecasted variables are explained by changes in relative prices and income. The models examined here do not make linkages among economic variables or depend on that type of causality. No particular type of behavior is postulated. Instead, we test the adequacy, for short run forecasting, of models based on market inertia or observable seasonal patterns and trends in unit sales. "Inertia" is here defined as a lack of responsiveness to economic conditions--sales occur in a regular, and by inference, predictable manner. This concept includes more than seasonality because established long- and short-term trends are assumed to continue. The models are referred to as stochastic processes since observations evolve through time according to a probability law.

These simple models are based on the assumption that the recent past is a good guide to the future--relative prices do not

matter in the econometric sense. Unlike econometric models that are difficult to construct and costly to update, this "stochastic noncausal framework" could perform with greater ease and less cost than behavioral models (3). These simpler forecasting models often produce accurate and inexpensive forecasts. An individual analyst, even without support of a large research staff, can forecast with these models.

The first forecasting model considered, the 5-year moving average, was chosen to conform with past research (8). The form of the forecasting model is

$$Y_t^* = \frac{1}{5} \sum_{i=1}^{5} Y_{t-12i} + e_t$$

where Y_t are tractor sales at time t and the superscript * represents a forecast value. For forecasting purposes, each series was treated as if it were generated by a stochastic process, with each value in the series randomly drawn from a probability distribution. That is, the forecast values were assumed to be made with some error, e_t. For simplicity, the errors are assumed to be distributed with zero mean and covariance, with a finite and constant variance.

Forecasting sales with a moving-average process can be problematic when actual sales exhibit a trend. The distant past can be very unlike the present in a trending series. Since a moving-average process weights the most distant past equally with the most recent past for forming forecasts, moving-average forecasts will lag a trending series--showing where sales have been rather than where they are going.

The second forecasting model, the random walk, is of the form

$$Y_t^* = Y_{t-12} + e_t$$

Here, each successive annual change in the series is assumed to be independently drawn from a probability distribution with characteristics identical to the previous error distribution. Each 12-month-ahead forecast depends only on the current observation--one year of monthly observations are used to forecast the following year. Penultimate and prior observations are irrelevant. This tool is considered important because it can take advantage of seasonal patterns and because it is relatively less sensitive to trend problems than is the moving-average model.

The third model considered, the ARIMA model, is one extension of the moving-average and random walk models. In the ARIMA model, the value of the series is a function of both lagged random disturbances (moving average) and its own past values (autoregressive) as well as a current disturbance term.

The ARIMA models used in this analysis were developed through the iterative technique of identification, estimation, and diagnostic checking popularized by Box and Jenkins (1). The procedure was repeated three times for each category of farm tractors as the time period for each was sequentially updated. That is, a model was estimated for each tractor category based on 1973-82 data, and each model was used to forecast monthly unit sales for 1983. Then, the three models were reestimated with 1973-83 data, forecasting 1984. Sales in 1985 were forecast with models estimated from 1973-84 data.

Each tractor time series appeared quite stable because model specification did not substantially change with each addition of 12 data points and the resulting parameter estimates were comparatively close (table 7). Generally large t-statistics support these conclusions. Only the four-wheel drive model specification changed over time, and that required no more than adding a parameter that was already in the two-wheel drive models. Models did differ between tractor categories, however. This difference occurred because monthly purchase patterns were not identical across all categories. The different purchase patterns can occur both from the demand side of the market and from dealer and manufacturer decisions on timing and magnitude of sales incentives.

To compare forecasting performance, each model was required to make a set of out-of-sample forecasts. These forecasts were compared with actual values, allowing the construction of statistics describing the size and types of forecast errors produced by each method. In many cases, a visual examination of forecast error time-plots was sufficient to rule out the use of some forecasting techniques as accurate predictors. Other cases were not so obvious, however. In the less obvious cases, knowledge of the size

Table 7--ARIMA models fitted to farm tractor sales series

Category	Model 1/ 2/		Estimates of parameters					
			1973-82		1973-83		1973-84	
			coeff.	t-stat	coeff.	t-stat	coeff.	t-stat
Two-wheel drive: 40-99 hp	$(1-B)(1-B^{12})Y_t=(1-\theta_1 B-\theta_2 B^2)(1-\theta_{12}B^{12}-\theta_{20}B^{20})e_t$	θ_1	0.512	5.21	0.529	5.75	0.514	5.92
		θ_2	0.178	1.80	0.183	1.98	0.205	2.35
		θ_{12}	0.559	6.26	0.522	6.17	0.510	6.45
		θ_{20}	0.173	1.81	0.200	2.29	0.201	2.44
Two-wheel drive: >100 hp	$(1-B)(1-B^{12})Y_t=(1-\theta_1 B-\theta_2 B^2)(1-\theta_{12}B^{12})e_t$	θ_1	0.429	5.13	0.469	5.20	0.505	5.85
		θ_2	0.210	2.18	0.243	2.68	0.232	2.66
		θ_{12}	0.559	5.80	0.632	8.09	0.661	9.12
Four-wheel drive	$(1-B)(1-B^{12})Y_t=(1-\theta_1 B-\theta_2 B^2)(1-\theta_{12}B^{12})e_t$	θ_1	0.496	5.79	0.507	6.36	0.401	4.58
		θ_2	-	-	-	-	0.173	1.97
		θ_{12}	0.715	8.72	0.726	9.79	0.701	9.24

1/ Where B, the backshift operator, shifts the subscript of a time series observation backward in time so that $B^x Y_t = Y_{t-x}$.
2/ Y_t=natural logarithm of farm tractor unit sales. Logarithmic transformations were made to all series because the natural logs of the series displayed greater spatial homogeneity.

and type of forecast error the forecast user most needs to avoid can allow generation of statistics reflecting the probability of different types of errors. These statistics can assist in choosing or ruling out the use of particular models.

The forecasts are exactly comparable because the ARIMA models are sequentially updated. This method of producing out-of-sample forecasts differs from adaptive forecasting (updating the forecast starting values without altering the model) because parameter estimates are updated. Sequentially updated forecasting incorporates new information in parameter estimates and is practical in this case because the models are easily updated--reestimation is the efficient way to use these tools. The moving-average and random walk models have no estimated parameters, so there is no real distinction between sequential updating and adaptive forecasting for these models. Each was used, like the ARIMA models, to make 36 out-of-sample forecasts, 12 months at a time (January 1983–December 1985).

Accuracy of Forecasts from Alternative Techniques

Visual comparisons can be made to evaluate how well the various predictions fit the sales data. Because the error patterns among forecasting models were very similar for each tractor category, only the best and worst fit tractor categories are graphed. The figures show that both the two-wheel drive 40–99 hp and the four-wheel drive tractors were poorly forecasted with the 5-year moving-average model. The forecasts are consistently far above the actual sales values, demonstrating that recent sales have declined too rapidly for a 5-year horizon to be useful. Clearly, the market has lacked the stability necessary for this model to adequately forecast sales. The other two forecasting models are not so easy to rank by visual inspection alone.

However, a number of commonly used statistics are available to evaluate and compare forecast accuracy. No single measure can describe all the qualities of an estimated model. Moreover, different evaluators will attribute differing levels of importance to various types of forecast errors. Five such statistics were constructed to assess the performance of the three forecasting models. These statistics provide a range of viewpoints on forecast error importance. The statistics are mean absolute error (MAE), mean absolute percentage error (MAPE), root mean square error (RMSE), the number of turning point errors (TPE), and Theil's inequality coefficient (U2) (2). Each statistic provides a different means of ranking the performance of the various forecasting

Tractor Forecasting Models

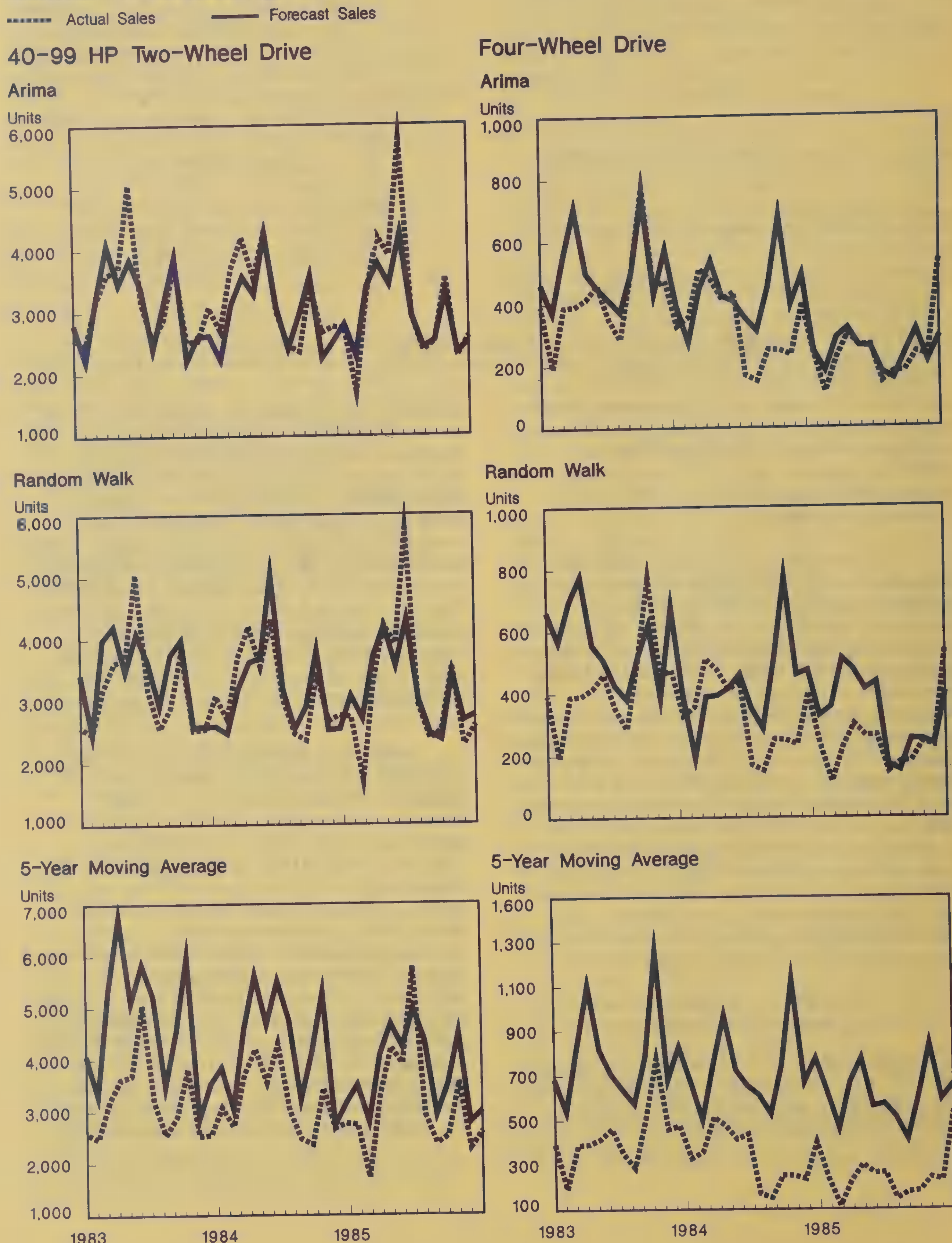

Table 8--Sales forecasts evaluated for three categories of farm tractors, 1983-85

Statistic	Two-wheel drive: 40-99 hp			Two-wheel drive: >100 hp			Four-wheel drive		
	5-year mov ave	Random walk	ARIMA	5 year mov ave	Random walk	ARIMA	5-year mov ave	Random walk	ARIMA
MAE	1097	394	307	1603	564	366	375	150	94
MAPE	35.7	12.6	9.2	92.2	32.8	20.9	138.7	56.0	35.0
RMSE	1275	515	443	1727	743	557	402	192	133
TPE	8	6	5	11	7	3	12	8	8
U2	0.98	0.50	0.45	2.38	0.83	0.66	3.47	1.39	0.97
Mean of monthly sales: 1983-85		3173			1953			333	
Maximum number		5773			4530			777	
Minimum number		1711			907			114	

techniques. Small numbers indicate better accuracy than large numbers for each statistic in table 8.

MAE is the average of all forecast errors. Errors are measured in absolute value form so that underestimates and overestimates do not balance to imply zero error. The magnitude of these errors can be appreciated when this error is compared to actual (1983-85) average monthly tractor sales of 1,953 units of over-100 hp two-wheel drives. Using the 5-year moving average to forecast monthly sales of this tractor series resulted in an average error of 1,603 units. The average monthly forecast error using a random walk model was 564 units, almost one-third of the moving-average error. The average error calculated from the ARIMA model, however, was smaller still at 366.

MAPE is the average percentage error. It provides the same information as MAE, but on a percentage basis. RMSE is included because it penalizes (produces larger RMSE values) a model more for large errors than does MAE. In some cases, the average error magnitude may not be a good criterion for ranking model forecast performance. For example, in cases where relatively small errors are tolerable, but large errors can be devastating, RMSE would be more appropriate than MAE because RMSE accounts for that differential error weighting.

TPE are forecasts that miss the direction of the actual values and are not errors of magnitude. This statistic counts the number of times the model has called for increased (decreased) sales when sales actually decreased (increased). For example, the moving-average model of four-wheel drive tractors made 12 turning point errors out of 36, pointing in the wrong direction one month in three, while the ARIMA model for the large two-wheel drives missed only three turning points from 1983 to 1985.

The Theil U2 has characteristics similar to RMSE, but is measured on a unit-free scale. If U2 were 0, the model would have forecast with perfect accuracy. Less than perfect accuracy generates larger U2 values. As a point of reference, a U2 value greater than 1 implies that the forecasting tool is less accurate than a month-to-month no-change extrapolation. An analyst ranking forecasting techniques by one of these statistics could object to using some of the models presented in this analysis because the "large" values of the statistics suggest that some of the models

fail to capture the true probability distribution and thus the true random behavior of the series.

Summary

Each of the diagnostic statistics yields the same ranking of forecasting accuracy for each series. All statistics show that the random walk performs much better than the moving-average models. The ARIMA models show the best performance overall, for each tractor category. Since the ARIMA model is a generalization of both techniques, it was expected prior to estimation to be better than the alternatives. It should be noted that ARIMA performance shown here could have been better if the models took greater advantage of either more frequent parameter reestimation or more frequent data updating. Forecasting a full year ahead with monthly ARIMA models without updating or reestimation is unusual, given the ease of such revisions and the sensitivity of forecasts to starting points. These models are designed for short run forecasting. However, forecasts were taken 12 periods ahead for exact comparability with the other techniques.

The out-of-sample forecasting was also performed over a period now recognized as difficult for agricultural input industries, 1983-1985. Aggregate demand dropped in the PIK year of 1983, while the farm machinery industry's decline in capital expenditures and unit sales that began in 1981 continued through 1985. A model able to adequately forecast across this arguably unusual period should be more than adequate under normal circumstances.

However, even the best of these models may not be sufficiently accurate for production or marketing decisions. The ARIMA models are inappropriate for long run planning because they assume unchanging economic conditions (in this case, declining sales over the long run). A model capable of forecasting a major turnaround in sales, at this time, would have to explicitly incorporate such factors as prices, farm income, and Government policies. That is, it is feasible for a structural model to exhibit greater long run forecast accuracy than an ARIMA model; however, that improvement comes at a cost. More resources must be devoted to forecasting with a structural model.

This analysis shows some patterns in farm machinery sales do exist and can be used to forecast. However, the degree of forecast accuracy using simple univariate models is mixed. The random walk procedure forecasts with an average 12.6 percent error for the smaller two-wheel drive tractors, but the accuracy of this tool falls by a factor of more than four for the four-wheel drive tractors. ARIMA models supplied the most accurate sales forecasts for all three categories of farm tractors. The large number of significant parameters in these ARIMA models suggest that there is a time pattern embedded in each series, but this pattern is neither simple nor obvious by examination of only the raw data.

Forecasts for 1986

Forecasts for 1986 were developed for each tractor series using the ARIMA models because of their superior forecast accuracy relative to the other techniques considered (table 9). The ARIMA models were updated by including monthly sales data through June 1986 and reestimated. The reestimated model for each series was used to forecast monthly sales for July through December. Annual unit sales estimates for 1986 were then constructed by adding actual unit sales totals through June to the forecasted values for July through December.

Table 9--Farm tractor unit sales forecasts for 1986 generated from ARIMA models

Unit Sales	Two-wheel drive: 40-99 hp	Two-wheel drive: >100 hp	Four-wheel drive
Actual January-June	16,217	9,272	955
Forecasted			
July	2,351	1,240	111
August	1,932	964	102
September	2,075	1,314	137
October	2,955	1,847	179
November	1,881	1,330	139
December	2,034	1,227	228
Forecast for 1986	29,445	17,194	1,851
Actual sales 1985	37,847	17,700	2,912
Change 1985 to 1986	-22.2%	-2.9%	-36.4%

Based on this procedure, unit sales of farm tractors, regardless of size, are forecast to fall from 1985 levels. Sales of 40–99 hp two-wheel drive tractors are forecast to fall by 22 percent to 29,445 units, while over-100 hp two-wheel drive sales may drop by 3 percent to 17,194 units. Unit sales of four-wheel drive tractors will show the largest percentage decline, as they are projected to fall by 36 percent from 1985 to 1,851 units.

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1985 TILLAGE PRACTICES—CORN AND SOYBEANS

by

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Abstract: Data from the 1984 and 1985 USDA Cropping Practices Surveys were analyzed to gauge the extent to which reduced tillage methods are used in corn and soybean production. Corn Belt farmers reported the largest percentage of corn and soybeans under reduced tillage, while Southeast and Delta farmers reported the fewest. Fewer over-the-field passes with larger horsepower (hp) tractors were characteristic of reduced tillage operations in both crops. In addition, the data indicate that farmers were more apt to use reduced tillage when planting corn or soybeans after a light residue crop.

Keywords: Tillage practices, corn, soybeans.

Introduction

Soil preparation for row crops traditionally has included the use of the moldboard plow to provide a suitable seedbed, incorporate nutrients, and control weeds. However, this type of tillage also makes most soils more susceptible to wind and water erosion. Reduced tillage, introduced in conjunction with the widespread development and application of herbicides for weed control, offers alternative techniques that allow crop

residues to remain on the soil surface to decrease potential erosion.

Farmer adoption of reduced tillage is closely tied to geographic location, which in turn is related to topography, soil type, climate, and commodities produced. Corn, soybean, and small grain production comprised approximately 90 percent of the total acreage worked under some form of reduced tillage practice in 1985 (1). Farmer attitudes and perceptions of returns to alternative tillage practices play an important role in adoption. Reduced tillage methods generally involve fewer field trips, which may lower fuel, labor, and machinery requirements.

In 1983, 21 percent of U.S. farmers used some form of reduced tillage practice: The frequency of use varied from 39 percent in the Corn Belt to 3 and 4 percent in the Delta and Southeast, respectively (5).

This article presents U.S. and State data from the 1984 and 1985 USDA Cropping Practices Surveys and provides insight into the number of field operations made, implements employed, and PTO hp used in practicing conventional and reduced tillage.

Based on the amount of residue remaining on the soil surface after planting, producers were asked to classify the tillage system used. Fields were randomly selected. Farmers specified the implements and tractor size (PTO hp) employed. Definitions of different tillage and cultivation systems used in this article are listed below.

Conventional tillage: Moldboard plowing or multiple disking plus other tillage operations are used to prepare a seedbed that incorporates nearly all of the crop residue.
No tillage before or at planting: The soil is left undisturbed since harvesting the last crop. Planting is done directly into the undisturbed soil by opening a slot 1 to 3 inches wide.
Strip planting: The soil is left undisturbed since harvesting the last crop. At planting, up to one-third of the soil surface is tilled in strips by a rototiller, in-row chisel, row cleaner, or similar implement to prepare a seedbed. The seed is placed in the tilled strip.
Ridge planting: Ridges are formed 4 to 6 inches high with a cultivator during the previous growing season. The top of each ridge is shaved off before or at planting. Seed is planted in the middle of each ridge. The field is cultivated after crop emergence to rebuild ridges or control weeds.
Other reduced tillage: The equipment used [chiseling, disking, etc.] leaves the field surface covered with some crop residue.

Implement types were classified according to degree of soil disturbance. Primary implements causing considerable soil inversion and breakage include the moldboard plow, chisel plow, hipping ridger, offset disk, and heavy-tandem disk. Secondary implements, those which generally involve limited soil breakage and inversion, include the disk harrow, spring harrow, field cultivator, do-all, and tine tooth harrow. In addition, data were collected on the number of times over the field with either a row cultivator, rolling cultivator, or rotary hoe after planting.

Trends in Reduced Tillage Practices

Corn

Acreage planted to corn under reduced tillage practices rose 11 percentage points from 1984 to 1985 (table 10). Acres of corn under no-till systems remained stable. The States surveyed represented 80 percent of the corn acreage harvested for grain. Apparently, 1985 was a significant year in the use of reduced tillage systems compared with 1980 (2). Iowa producers had the greatest percentage of corn acreage under some type of reduced tillage regime (70 percent), while South Dakota farmers reported the fewest (23 percent). However, corn acreage under reduced tillage increased over 1.5 times (from 9 to 23 percent) in South Dakota between 1984 and 1985, the largest gain of the States surveyed.

Although 96 percent of corn acreage in the surveyed States was treated with herbicides, South Dakota reported only 76 percent (7). This may explain why that State had the highest average number of machinery

Table 10--Corn acreage by tillage system

State	Conventional		No-till systems 1/		Reduced-till	
	1984	1985	1984	1985	1984	1985
	Percent					
Ill.	51	43	4	4	45	53
Ind.	71	52	9	10	20	38
Ia.	30	26	5	4	65	70
Mich.	68	58	8	5	24	37
Minn.	80	57	2	2	18	41
Mo.	48	48	9	5	43	47
Neb.	74	59	5	8	21	33
Oh.	62	58	18	12	20	30
S.D.	90	77	1	nr	9	23
Wis.	80	68	2	3	18	29
Average 2/	59	49	6	5	35	46

nr = none reported

1/ Includes ridge- and strip-till. 2/ 1980 data: conventional - 59 percent; no-, and strip-till - 1 percent; and reduced-till - 40 percent.

field passes (4.9 and 3.8 under conventional and reduced tillage, respectively), and implies a greater reliance on mechanical cultivation rather than herbicides for weed control (table 11). Average post-planting cultivations under reduced tillage regimes in South Dakota were greater than any other reporting State at 1.6 times over the field.

Ohio farmers reported the largest percentage of corn acreage under a no-till system (12 percent), and acreage under reduced tillage rose from 20 percent in 1984 to 30 percent in 1985.

The frequency of post-planting cultivations did not differ significantly between tillage systems in corn production. Farmers reported an average of approximately one post-planting cultivation under both the conventional and reduced tillage systems.

The substantial increase in the share of acreage under some method of reduced tillage may have been affected by farmers' response to market pressures to alter input use patterns. Annual realignment of production decisions can often be traced to prices received and paid at the farm gate. For example, the average farm price for corn dropped from $3.25 per bushel in 1983 to $2.69 in 1984 (8). Production decisions for 1984 and 1985 probably reflected the previous year's prices received. Magleby, et al. report that in a 1983 USDA survey of 11,000 U.S. farmers, 40 percent responded that soil and water conservation and cost and time savings were of equal importance in the use of reduced tillage. After a year of low crop prices, a greater percentage of farmers may choose a reduced tillage method for the following season due to cost considerations alone. This implies that farmers either owned or had access to the implements necessary to practice a reduced tillage regime. Reduced tillage systems may enhance income through decreased machine, energy, and labor costs.

The 10-State average for implement use in reduced tillage systems was 3.2 times over the field versus 3.9 passes under a conventional tillage regime, a difference of 17 percent (table 11). In addition, use of both primary and secondary tillage implements was

Table 11--Number of times tillage implements were used on 1985 corn acreage

State	Implement category: Preplant Primary	Preplant Secondary	Postplant cultivating	Total
	Conventional tillage			
Ill.	1.40	1.63	1.02	4.05
Ind.	1.39	1.28	0.64	3.31
Ia.	1.29	1.30	1.11	3.70
Mich.	1.23	1.53	0.58	3.33
Minn.	1.18	1.66	1.41	3.87
Mo.	1.65	1.00	0.75	3.40
Neb.	1.56	0.92	1.40	3.87
Oh.	1.38	1.53	0.65	3.55
S.D.	1.48	1.42	1.95	4.86
Wis.	1.41	1.63	0.77	3.80
Average	1.39	1.40	1.08	3.86
Average HP 1/	153	149	117	
	Reduced tillage 2/			
Ill.	0.97	1.52	0.82	3.31
Ind.	1.14	1.15	0.85	3.14
Ia.	1.01	1.11	1.13	3.25
Mich.	1.24	1.05	0.49	2.78
Minn.	1.07	1.40	1.15	3.61
Mo.	1.48	0.92	0.54	2.93
Neb.	1.17	0.75	1.18	3.11
Oh.	1.30	1.00	0.36	2.66
S.D.	1.32	0.84	1.60	3.76
Wis.	1.17	1.15	0.65	2.98
Average	1.09	1.18	0.96	3.22
Average HP 1/	170	166	118	

1/ Reflects power takoff horsepower. 2/ Does not include no-, ridge-, and strip-till.

less under reduced tillage. The 10-State average for times over the field under conventional tillage using primary implements was 1.4 passes, versus 1.1 under reduced tillage, a difference of 22 percent. Secondary implements were used in 1.4 passes under conventional till and 1.2 passes in reduced tillage, a 16-percent advantage for reduced tillage.

Reported average PTO hp capacity used in conventional preplant tillage systems when operating with primary or secondary tillage implements averaged 151 hp, while average capacity employed for post-planting weed control was 117. A similar comparison for reduced tillage indicates that 168 hp was employed for preplant operations, while 118 hp was reported for post-planting weed control. This may indicate larger farms may be more disposed to practicing reduced tillage.

Soybeans

Acreage trends under reduced tillage practices for soybeans are similar to those for corn (table 12). Though no discernable trend is evident when comparing 1980 and 1984 figures, the share of acreage under reduced tillage regimes rose sharply in 1985. No-till acreage increased from 1980 to 1984, but remained stable in 1985.

Table 12--Soybean acreage by tillage system

	Conventional		No-till systems 1/		Reduced-till	
State	1984	1985	1984	1985	1984	1985
			Percent			
Ala.	88	83	nr	6	nr	11
Ark.	94	99	3	nr	3	1
Ga.	92	88	5	2	3	10
Ill.	68	56	3	2	29	42
Ind.	77	68	9	4	14	28
Ia.	38	38	2	1	60	61
Ky.	--	54	--	20	--	26
La.	93	100	6	nr	1	nr
Minn.	83	56	1	3	16	41
Miss.	83	77	7	4	10	19
Mo.	63	46	5	3	32	51
Neb.	68	60	4	9	28	31
N.C.	73	72	21	21	6	7
Oh.	80	66	8	6	12	28
S.C.	86	--	11	--	3	--
Tenn.	88	84	8	5	4	11
Average 2/	72	63	5	4	23	33

-- = not sampled
nr = none reported

1/ Includes ridge- and strip-till. 2/ 1980 data: conventional - 72 percent; no-, ridge-, and strip-till - 2 percent; and reduced-till - 26 percent.

Regional differences in soybean tillage practices are significant. Acreage under some type of reduced tillage regime in the Southeast and Delta generally remains well below that in other production regions. Louisiana and Arkansas farmers reported virtually all soybean acreage under conventional tillage systems, while Alabama, Georgia, Mississippi, and Tennessee farmers reported between 77 and 88 percent of their soybean acreage under conventional tillage in 1985. However, soybean acreage under reduced tillage increased in several of the above States. In Alabama, soybean acreage under reduced-till increased from none reported in 1984 to 11 percent in 1985. In Georgia, reported soybean acreage under reduced tillage rose from 3 percent to 10 percent. Other southeastern States reporting increased reduced-till acreage include Mississippi (from 10 to 19 percent) and Tennessee (from 4 to 11 percent). North Carolina farmers reported the greatest share of soybean acreage produced under a no-till regime, 21 percent. In North Carolina, over 70 percent of 1985 soybean acreage followed a wheat crop, which provides a light postharvest crop residue.

Corn Belt farmers continue to be leaders in the adoption of reduced tillage practices in soybean production with acreage ranging from 28 percent in Ohio to 61 percent in Iowa. The region is particularly suited to reduced tillage practices due to its climate, topography, and rich but erodible soils. The practice of no-till, however, generally remains rare with only Nebraska reporting as much as 9 percent of soybean acreage under a no-till system.

The significant increase in the share of soybean acreage under reduced tillage systems in the major U.S. production regions may indicate either reaction to market pressures or acceptance of minimum till concepts. The large drop in the average farm level price of soybeans from $7.81 per bushel in 1983 to $6.13 in 1984 may have altered input decisions for the 1985 production season; farmers may

Table 13--Number of times tillage implements were used on 1985 soybean acreage

State	Implement category: Preplant Primary	Preplant Secondary	Postplant Cultivating	Total
	Conventional tillage			
Ala.	1.94	1.45	1.54	4.93
Ark.	2.29	1.90	2.19	6.38
Ga.	1.58	1.57	2.12	5.27
Ill.	1.53	1.71	1.10	4.34
Ind.	1.40	1.60	1.32	4.32
Ia.	1.46	1.65	1.61	4.72
Ky.	1.81	1.36	0.79	3.95
La.	2.29	1.91	1.58	5.78
Minn.	1.05	2.07	1.44	4.56
Miss.	2.17	2.01	1.67	5.86
Mo.	1.95	1.21	0.92	4.09
Neb.	1.33	1.18	1.12	3.63
N.C.	2.31	0.57	1.26	4.15
Oh.	1.37	1.57	1.00	3.95
Tenn.	2.04	1.96	1.37	5.37
Average	1.72	1.65	1.43	4.80
Average HP 1/	157	153	119	
	Reduced tillage 2/			
Ala.	1.56	0.67	0.67	2.89
Ark.	nr	1.00	1.00	2.00
Ga.	1.29	1.29	1.86	4.43
Ill.	1.23	1.72	1.18	4.13
Ind.	1.40	1.40	1.53	4.33
Ia.	1.36	1.43	1.55	4.35
Ky.	1.20	1.20	0.55	2.95
La.	nr	nr	nr	nr
Minn.	1.19	1.74	1.19	4.12
Miss.	1.24	2.19	1.14	4.57
Mo.	1.39	1.10	0.75	3.24
Neb.	1.36	0.84	1.48	3.68
N.C.	1.00	0.43	0.43	1.86
Oh.	1.00	1.59	0.78	3.38
Tenn.	1.30	1.90	1.20	4.40
Average	1.29	1.47	1.22	3.98
Average HP 1/	168	168	117	

nr = none reported

1/ Reflects power takeoff horsepower. 2/ Does not include no-, ridge-, and strip-till.

have adopted a cost-reducing tillage system after receiving disappointing prices for their 1984 soybean crop (8).

Farmers reported making approximately 4 machinery passes over their fields under a reduced tillage regime, compared with 4.8 passes under conventional tillage, a 17-percent decrease (table 13). In addition, average times over the field using primary tillage implements were 25 percent lower than conventional till. Post-planting cultivation was significantly less in the Southeast and Delta under reduced tillage, though Corn Belt farmers in general reported post-planting field passes under reduced tillage equal to or greater than conventional practices.

Summary

Soybean production required more field passes than corn production in each tillage comparison. Soybeans under conventional tillage required an average of 4.8 passes using primary and secondary implements for preplant tillage and cultivation implements for post-planting weed control. Corn production under the same system required an average of 3.9 passes. Soybeans under a reduced-till regime required an average of 4 field passes, while corn averaged 3.2. These differences may be attributed to crop rotation practices common among corn and soybean producers. Soybeans following corn generally require more tillage to prepare a suitable seedbed in heavy residue. Corn after soybeans, however, requires less tillage since the soybean residue is lighter and more easily incorporated.

Implications

Future adoption of reduced tillage practices is difficult to project based upon 1984-1985 data. In the short term, it appears that producers are content to switch from conventional to reduced tillage methods as market forces dictate, adjusting input use to suit prevailing market conditions. In many instances, using a no-till regime makes it possible to produce a second intraseason crop. Short-run costs may be higher if tillage equipment purchases are required, though in the long term, cost savings are possible through reduced labor requirements, fuel, and the need for complementary pieces of equipment.

If herbicide prices were to decline relative to prices for other production inputs as they did in 1984 and 1985, fewer tillage operations may result. Herbicide use combined with some tillage operations are effective production substitutes for conventional till. Alternatively, a continued decline in gasoline and diesel fuel costs could result in increased conventional tillage, particularly if other input costs remain unchanged or increase. Incidences of weed or soil compaction problems in specific fields may cause producers to revert to conventional tillage from time to time.

Further, continuing financial stress in many production regions may influence reduced tillage use and the share of acres under these systems. Rahm and Huffman have reported (in an Iowa study) that the larger a farm's corn acreage, the more likely that reduced tillage technology will be adopted. As insolvent farmers sell their land to neighboring producers whose scale of production is increased, adoption of reduced tillage practices may expand.

Distress sale of farmland to absentee landlords also may influence total acreage under reduced tillage practices. Lee and Stewart, evaluating a nationwide cultivated cropland survey, report higher minimum tillage adoption rates among nonoperator owners and among landowners with large holdings than among owner-operators and relatively small-scale operations. Reduced tillage methods may be perceived to be a cost-savings measure and attractive to a tenant in a cash lease operation. In addition, both tenants and owner-operators of large holdings may have the financial ability and production capability to assume the risks of new technology adoption.

Although corn and soybean acreage under some type of reduced tillage varies widely by region, year-to-year changes in tillage practices appear to be linked to market conditions as well as to structural changes taking place in many agricultural regions. Increases in corn and soybean acreage under reduced tillage practices in 1985, compared with 1984, while characteristic of a trend in increased adoption since 1980, may be attributable to factors other than comprehensive technological acceptance and implementation. The 1983 Payment-In-Kind program may have influenced 1984 production practices as participants brought idled acreage back into production. Moldboard plowing might therefore have increased in 1984, inflating the use of conventional tillage. If that was the case, many farmers in 1985 simply may have been reverting to a reduced tillage system rather than becoming new adopters. Additional annual production data are necessary to determine if reduced tillage methods are gaining increased acceptance nationwide, or whether we are simply witnessing farmers' reactions to various policy mandates.

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ENERGY

U.S. farmers can expect plentiful supplies of refined petroleum products at lower prices during the remainder of this year. Since last year, prices paid by farmers for diesel and gasoline fuels have fallen nearly 27 percent, which, along with reduced planted acres, will likely translate into a $1-billion savings in production expenditures. Farm energy availability and prices are closely linked to the national and world oil markets, where crude oil prices have declined 38 percent since last year.

World Oil Market

Petroleum Consumption

Petroleum prices and the pace of economic growth in the world's industrial countries will largely determine petroleum consumption this year and next. Lower crude oil prices and continued economic growth, expected to be near 3 percent in the industrial countries during 1986, are likely to support a 2-percent increase in petroleum consumption over 1985. Increased oil demand in the market economies, particularly the United States, several developing countries, and Europe, is expected to push 1986 consumption over 46 million barrels per day.

Crude Oil Production

Nearly all the members of the Organization of Petroleum Exporting Countries (OPEC) and non-OPEC oil producing countries are projected to increase their crude oil production in 1986. The market economies' oil production is expected to increase 3 percent to over 45 million barrels per day. Total OPEC oil production may increase about 7 percent to 18.3 million barrels per day, with Saudi Arabia contributing nearly 80 percent of the growth. In an attempt to increase or maintain oil revenues as prices decline, several non-OPEC developing countries such as Mexico have increased their production for the export market. Net 1986 exports from the centrally planned countries are expected to fall about 6 percent below 1985.

World Oil Prices

With world oil supplies increasing faster than demand, prices have fallen precipitously since the beginning of this year. The major factor underlying this development has been a concerted attempt by OPEC producers to maintain oil revenues and their share of the world oil market, which has led to increased production. OPEC's share of total world oil production had declined 20 percentage points between 1978 and 1985, resulting in a 46-percent drop in its output. Until third-quarter 1985, Saudi Arabia had been acting as a swing producer, curtailing its production to make up for the excess production of others. Thus, it helped maintain high oil prices despite weakened demand, especially in the industrialized countries.

In fourth-quarter 1985, OPEC countries increased production 3 million barrels per day. The downward pressure on oil prices exerted by the expanded OPEC supply has been reinforced by increased non-OPEC production and a drawdown of inventories in the oil consuming countries.

U.S. Energy Outlook

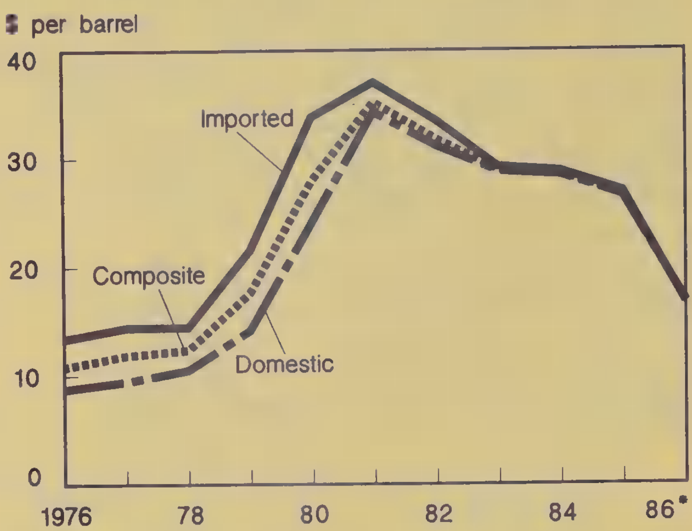
Petroleum Prices

A variety of quotes are available for domestic crude oil prices. For example, three prices are quoted for West Texas Intermediate Crude, which serves as a domestic benchmark. These include spot prices, futures prices, and posted or contract prices. Spot prices, as the name implies, are cash prices that are paid on the spot. Spot prices are determined in the marketplace by the interaction of demand and supply and change daily. Oil futures serve to transfer price risk from refiners to speculators. These prices are typically quoted for deliveries to be made at a specified future date, usually within 3 months. Very little oil actually changes hands under futures contracts.

Most oil is sold to refiners under contract prices. These contracts guarantee deliveries of specified quantities on specified dates, but do not guarantee prices, which are determined or posted by the refiners and are, therefore, known as posted prices. Posted prices are much less volatile than the spot market or futures prices. That is why, despite plummeting spot oil prices, the average prices paid by consumers change less rapidly.

The refiner's cost of acquiring crude oil is a composite price that is the weighted average

Prices Paid by Refiners for Crude Oil



* 1986 Projected.

of the domestic (posted) and imported crude oil prices. The refiner's cost of imported crude oil peaked in 1981 at $37 per barrel. Since then, despite continued growth in the economy, petroleum demand has not picked up because of continuing conservation efforts, efficiency improvements, and fuel switching.

With increased oil production, oil prices have fallen steadily over the last 4-1/2 years, declining to $27 per barrel in 1985, 27 percent below the peak year. The domestic price remained well below imported prices until 1981 because of oil price controls. With decontrol of oil prices, domestic and imported prices have converged and are both forecast to average about $17 per barrel for 1986.

Petroleum Supplies Unchanged

Total U.S. petroleum supplies, which include domestic oil, net imports, natural gas liquids, processing gain, and other hydrocarbon and alcohols, remained unchanged in 1985 from 1984 at 15.6 million barrels per day (table 14). In 1986, supplies are projected to increase 2 percent primarily due to increased imports.

U.S. crude oil production in 1986 is projected to decline to 8.8 million barrels per day, from nearly 9 million in 1985. Even with plummeting crude oil prices, domestic production will decline only moderately, as

Table 14--U.S. petroleum consumption-supply balance

Item	1983	1984	1985	Projections 1986	Projections 1987
		Million barrels per day			
Consumption:					
Motor gasoline	6.62	6.69	6.82	7.00	7.14
Distillate fuel	2.69	2.84	2.86	2.99	2.86
Residual fuel	1.42	1.37	1.19	1.15	1.11
Other petroleum 1/	4.50	4.82	4.82	4.99	4.88
Total	15.23	15.72	15.69	16.13	15.99
Supply:					
Production	10.79	11.17	11.19	11.08	11.01
Net imports (excludes SPR)	4.08	4.52	4.14	4.81	4.74
Net stock withdrawals	0.25	-0.08	0.22	0.00	0.00
Total	15.12	15.61	15.55	15.89	15.75
Net imports as a percent of total supply	26.90	28.90	26.60	30.20	30.10
		Percent change from previous year			
Consumption		3.2	-0.2	2.8	
Production		3.5	0.2	-1.0	
Net imports		10.8	-8.4	16.2	

SPR = Strategic Petroleum Reserves.

1/ Includes crude oil, pentanes plus, other hydrocarbons and alcohol, unfinished oil, gasoline blending components and jet fuel.

Source: U.S. Department of Energy, Energy Information Administration. Short-Term Energy Outlook. DOE/EIA - 0202 (86/2Q), April 1986.

most existing wells have variable production costs well below the anticipated prices. In 1984, the average U.S. oil lifting cost was $7.04 per barrel. In general,producing wells that are most vulnerable to lower oil prices are those having relatively high operating costs such as low-yield stripper wells.

Net oil imports, excluding imports for the Strategic Petroleum Reserve (SPR), were 4.1 million barrels per day in 1985, down 8.4 percent from 1984. Net oil imports are projected to average 4.8 million barrels per day this year. The share of total petroleum supply attributable to net imports (excluding SPR) was 27 percent in 1985, but is projected to increase to 30 percent in 1986.

Consumption Steady

Total petroleum product consumption in the United States in 1985 was unchanged from the 1984 level of 15.7 million barrels per day. Consumption this year is projected to increase nearly 3 percent to 16.1 million barrels per day in response to sharp declines in oil prices. The relatively small increase in consumption, despite a significant price drop, implies that gains in conservation and efficiency, and increased fuel switching that occurred when oil prices were skyrocketing in the late 1970's and early 1980's are not expected to be reversed in the near future.

With increased highway travel, adequate supplies, and falling prices, motor gasoline demand rose about 2 percent between 1984 and 1985 from 6.7 million barrels per day to 6.8 million. An expected 5-percent increase in miles driven this summer and an anticipated 3.6-percent increase in disposable personal income are expected to push gasoline demand 2.6 percent higher this year to an average of 7 million barrels per day.

Consumption of distillate fuel, which consists of diesel and fuel oil, totaled 2.86 million barrels per day in 1985, about the same as in 1984. Consumption this year is expected to rise to almost 3 million barrels per day, due to the sharp decline in oil prices. Lower prices and economic growth of about 3 percent is expected to raise industrial demand for distillate. Increased economic activity is expected to boost transportation demand for medium and large trucks, which typically are diesel-powered. Some conversions of trucks from gasoline-powered to diesel-powered also are occurring in response to the phasedown of lead in gasoline.

Demand for residual fuel oil, which includes heavy oils used primarily for electric power generation and space heating, continued to decline during 1985 for the eighth consecutive year. Total consumption of residual fuel oil declined more than 60 percent between 1977 and 1985, the largest decrease among major petroleum products. During this period, electric utilities accounted for most of the drop because of continued substitution of natural gas for residual fuel oil in power generation. In 1986, total residual fuel demand is projected to fall only 3.4 percent as consumption by electric utilities is projected to increase.

Natural Gas

In 1986, natural gas consumption is projected to decline 1.6 percent from last year to about 17 trillion cubic feet. Because of lower oil prices compared with natural gas, electric utilities are projected to switch to more oil-fired electric generation in 1986. As a result, the slight increase in natural gas consumption for other uses is expected to be more than offset by sharply lower use by electric utilities and reduced consumption due to warmer-than-normal weather in the first quarter of this year.

Natural gas prices are expected to fall in 1986. In the electric utility sector, they are expected to fall about 20 percent--much lower than in other sectors, because of intense competition among natural gas pipelines and distributors and from lower priced oil. Natural gas prices in the residential sector are projected to decrease by 4 percent, following almost no price change in 1985.

Natural gas production is projected to remain virtually unchanged between 1985 and 1986, but will likely increase 2 percent between first-half 1986 and first-half 1987. Natural gas imports from Canada are projected to increase to approximately 1 trillion cubic feet in 1986.

Electricity

Electricity generation is projected to increase more than 2 percent from 1985 to 2,522 billion kilowatt hours. Electricity prices to nonindustrial consumers in 1986 are expected to rise only 1 percent, compared with 4 percent last year.

Declining fuel costs, which represent about 33 percent of the total price of electricity, and continued lower capital costs are expected to contribute to the slowdown in rate increases.

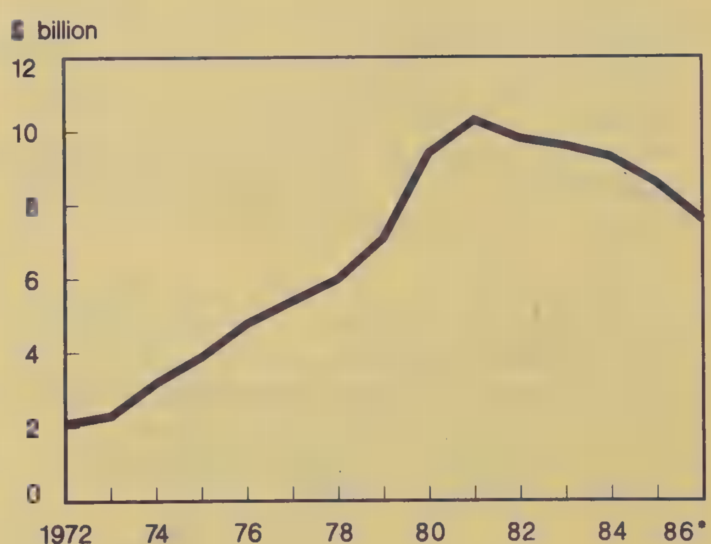
Energy in the Farm Sector

Expenditures

Annual farm energy expenditures rose dramatically during the 1970's as petroleum prices nearly tripled and planted acreage increased. Energy expenditures peaked in 1981 and have declined ever since, due to lower energy prices, energy conservation efforts, and a reduction in planted acreage as farmers' participation in various commodity programs rose. In 1985, energy expenditures declined about 8 percent from a year earlier to $8.6 billion. Energy's share of total agricultural production expenditures was 6.3 percent, down from a peak of nearly 8 percent in 1981. In 1986, farmers are projected to spend $7.6 billion on energy, down $1 billion from 1985.

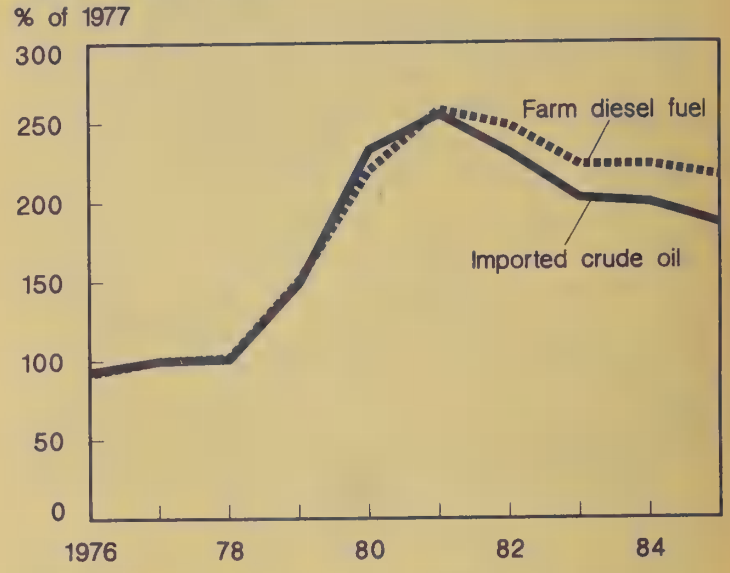
Farm diesel fuel prices appear highly correlated with world crude oil prices.

Farm Energy Expenditures



* 1986 projected.

Prices Indices of Imported Crude Oil and Farm Diesel Fuel



Between 1976 and 1981, price indices for diesel fuel and crude oil moved in the same pattern, but since 1982 the price index for crude oil has fallen more rapidly than the price index for diesel fuel.

Utilization

Although farm energy use constitutes only a small fraction of total U.S. energy use, energy is an extremely important farm input. Gasoline, diesel fuel, LP gas, natural gas, and electricity are used directly in crop, livestock, and poultry production and marketing. Energy also is encompassed in other manufactured inputs such as fertilizer and pesticides. In 1981, for example, nearly 41 percent of the energy used in producing crops and livestock was consumed in the manufacture of fertilizer and pesticides.

Table 15--Farm fuel use

Year	Gasoline	Diesel	LP gas
		Billion gallons	
1974	3.7	2.6	1.4
1975	4.5	2.4	1.0
1976	3.9	2.8	1.2
1977	3.8	2.9	1.1
1978	3.6	3.2	1.3
1979	3.4	3.2	1.1
1980	3.0	3.2	1.1
1981	2.7	3.1	1.0
1982	2.4	2.9	1.1
1983	2.3	3.0	0.9
1984	2.1	3.0	0.9
1985	1.9	2.9	0.9

Table 16--Average U.S. farm fuel prices 1/

Year	Gasoline	Diesel fuel	LP gas
	Dollars per gallon 2/		
1977	.57	.45	.39
1978	.60	.46	.40
1979	.80	.68	.44
1980	1.15	.99	.62
1981	1.29	1.16	.70
1982	1.23	1.11	.71
1983	1.18	1.00	.77
1984	1.16	1.00	.76
1985	1.15	.97	.73
1986			
April	.84	.70	.67
July	.84	.59	.64

1/ Based on surveys of farm supply dealers conducted by the National Agricultural Statistics Service, USDA. 2/ Bulk delivered.

On-farm gasoline and diesel fuel use declined 9.5 and 3.3 percent, respectively, last year, whereas LP gas use remained unchanged (table 15). Diesel fuel use, however, continues to increase relative to gasoline as older gasoline-powered machinery is progressively replaced by diesel-powered machinery. Fuel use in 1986 is projected to decline further with reduced planted acreage and continued adoption of energy-saving farm production technologies.

Prices

In 1985, farmers paid an average of $1.15 a gallon for bulk delivered gasoline, $0.97 a gallon for diesel, and $0.73 a gallon for LP gas (table 16). Gasoline prices fell 1 cent per gallon from 1984, whereas diesel fuel and LP gas declined 3 cents. Farm fuel prices have fallen dramatically in 1986, with July diesel prices down the most at 39 percent. Gasoline prices have dropped 27 percent and LP gas is down 12 percent.

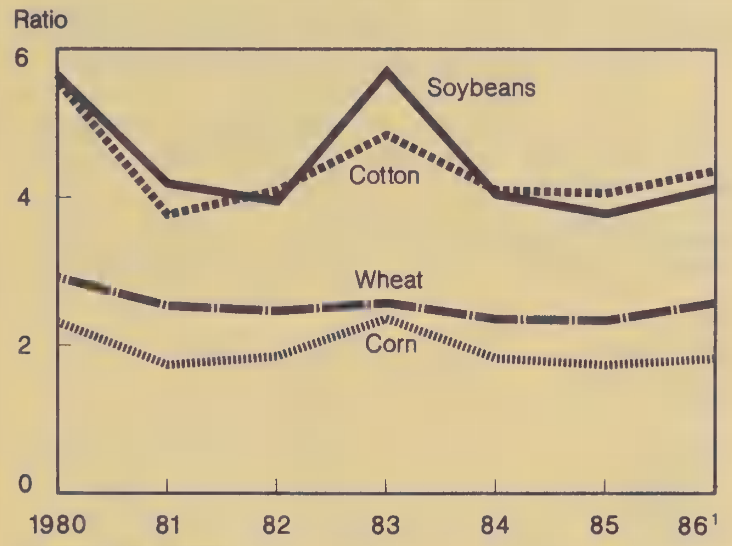
FERTILIZER

Use

Plant nutrient use in 1985/86 is projected to be about 20.6 million tons, down about 5 percent from a year earlier, due primarily to reduced plantings, especially corn.

Fertilizer application rates are expected to be close to year-earlier levels. Prices for all major crops will be below 1985, but fertilizer prices have also fallen. The ratio of crop to fertilizer prices has been stable the

Crop-to-Fertilizer Price Ratios



1/ January-April estimate.

past few years. In addition, falling energy prices and interest rates should help alleviate some farmers' cash or credit problems and reduce the financial stress of recent years that may have restricted input use.

Supplies

Domestic fertilizer supplies in 1985/86 were down from last year, but adequate to meet this year's crop needs. During July-April, supplies of nitrogen were down 1 percent, while potash supplies were off 11 percent (table 17). Phosphate supplies also were down, but supplies were overstated because the U.S. Department of Commerce ceased publishing export data for superphosphoric acid in 1985/86. This change in data reporting procedures understates phosphate exports, resulting in an overstatement of domestic supplies.

Trade

Plentiful world fertilizer supplies and low prices in 1984/85 have affected this year's U.S. fertilizer exports. In 1984/85, low phosphate fertilizer prices resulted in record exports with shipments to India and China rising to unprecedented levels. Imports by several Asian countries during 1984/85 caused supplies to exceed use, resulting in a stock buildup at the beginning of 1985/86. In response to ample stocks, China, India, Taiwan, and Japan began restricting 1985/86 imports. Exports to China also were affected by that country's policy to conserve foreign exchange.

Table 17--U.S. fertilizer supplies 1/

Item	1984/85	1985/86	Change
	Million short tons		Percent
July 1 inventory:			
Nitrogen (N)	1.66	1.42	-15
Phosphate (P_2O_5) 2/	.81	.77	-5
Potash (K_2O)	.31	.30	-3
Production:			
Nitrogen	11.55	10.24	-11
Phosphate 2/	9.58	7.95	-17
Potash	1.35	.98	-27
Imports:			
Nitrogen	3.04	3.46	+14
Phosphate 2/	.11	.09	-18
Potash	4.45	4.21	-5
Exports:			
Nitrogen	2.79	1.71	-39
Phosphate 2/	3/ 4.42	3/ 2.63	-41
Potash	.47	.41	-13
Domestic Supply: 4/			
Nitrogen	13.46	13.41	-1
Phosphate 2/	3/ 6.08	3/ 6.18	-2
Potash	5.64	5.05	-11

1/ Data for July through April for the fertilizer year starting July 1. 2/ Does not include phosphate rock. 3/ Does not include exports of superphosphoric acid because of a data reporting change by the U.S. Department of Commerce in July 1985. Thus, phosphate exports are understated and domestic supply is overstated. 4/ Includes requirements for industrial uses.

Phosphate exports, excluding superphosphoric acid, declined 41 percent in 1985/86 (table 17). Most of the decline was due to a 49-percent drop in diammonium phosphate exports, which fell 3.4 million tons and accounted for 89 percent of the 1.8-million-ton drop in exports of phosphate nutrients. Diammonium phosphate shipments to China dropped 1.3 million tons, essentially taking China out of the market in 1985/86. Exports of diammonium phosphate to India, Taiwan, and Japan were down 60 percent, reducing U.S. exports of this phosphate fertilizer material another 1.5 million tons.

The combination of plentiful world fertilizer supplies and sagging demand created intense competition in the world nitrogen and potash fertilizer markets. The inability of the U.S. nitrogen and potash fertilizer industries to effectively compete with foreign producers caused nitrogen and potash exports to fall. From July 1985 to April 1986, nitrogen exports declined 39 percent because of a 51-percent decline in urea exports, a 30-percent drop in anhydrous ammonia exports, and the decline in diammonium phosphate exports. A halving of potassium chloride sales to Latin America caused potash exports to decline about 13 percent.

In 1985/86, nitrogen imports were up 14 percent, reflecting a 57-percent increase in urea imports. A significant growth in world urea supplies, mainly from Eastern European countries, has pushed prices down. The low prices have encouraged urea imports at the expense of U.S. production.

Production

Reduced domestic use, fewer exports, and more nitrogen imports have resulted in lower fertilizer production. Domestic nitrogen production declined 11 percent during July-April. Phosphate and potash production were down 17 and 27 percent, respectively.

Prices

Because of plentiful supplies and reduced use, farm fertilizer prices in April 1986 averaged about 8 percent below a year earlier. The pressure from low-priced imports caused urea prices to drop the most--20 percent. Prices of other nitrogen products generally were down about 10 percent with anhydrous ammonia prices falling 11 percent (table 18). Triple superphosphate prices declined about 6 percent, while muriate of potash prices dropped 13 percent.

Table 18--Average U.S. farm prices for selected fertilizer materials 1/

Year	Anhydrous ammonia (82%)	Triple super-phosphate (44-46%)	Diammonium phosphate (18-46-0%)	Potash (60%)	Mixed (6-24-24%)
	Dollars per short ton				
1983	237	214	249	143	206
1984	280	231	271	147	217
1985	252	203	240	128	192
1986	225	190	224	111	179

1/ Based on surveys of farm supply dealers conducted by the National Agricultural Statistics Service, USDA. Prices are May prices for 1983-85 and April prices for 1986.

Table 19--Projected pesticide use on major U.S. field crops

Crop	June 1, 1986 planted acreage	Herbicides	Insecticides	Fungicides
	Million	Million pounds (active ingredients)		
Row:				
Corn	76.6	232	26.3	0.07
Cotton	9.7	15	14.4	.15
Grain sorghum	15.0	15	2.5	0
Peanuts	1.5	5	1.1	5.24
Soybeans	61.8	110	9.6	.06
Tobacco	.6	1	2.5	.33
Total	165.2	378	56.4	5.85
Small grains:				
Barley and oats	28.0	7	.2	0
Rice	2.3	10	.4	.05
Wheat	72.0	15	2.0	.82
Total	102.3	32	2.6	.87
Total	267.5	410	59.0	6.72

PESTICIDES

Demand

Total 1986 farm pesticide use on major field crops is projected to be 475 million pounds, active ingredients (a.i.), down from 505 million pounds in 1985 (table 19). Planted acreage for the 10 major field crops declined from 281 million in 1985 to 268 million in 1986. In absolute terms, the largest decline was in corn, with planted acreage down 6.6 million (8 percent) from 1985.

Farm herbicide use is projected at 410 million pounds (a.i.) in 1986 with corn and soybeans accounting for 83 percent. The corn crop is expected to use 26 million pounds of insecticides, followed by cotton at 14.4 million pounds. Peanut production is the major user of fungicides.

Prices

Average farm-level herbicide prices remained stable between 1985 and 1986 at $4.05 per pound (a.i.) (table 20). However, atrazine prices increased about 5 percent, while 2,4-D prices declined 5 percent.

In general, farm-level insecticide prices are down about 2 percent this year, compared with a 5.5-percent increase in 1985. Corn rootworm insecticides, carbofuran, fonofos, phorate, and terbufos were priced less than a year earlier. Among all insecticides, methyl parathion prices increased the most at 4.2 percent. Synthetic pyrethroid prices are about $51 per pound (a.i.) in 1986, down 6.2 percent from 1985. Since 1982, synthetic pyrethroid prices have declined 25 percent per pound because of increased competition from second-generation products.

Regulatory Actions

Following is a summary of Special Reviews being conducted by the Environmental Protection Agency (EPA) for pesticides used in agriculture. The public is informed of the initiation of a Special Review with the publication of the risk analyses, Position Document (PD) 1. EPA presents its proposed regulatory decision in PD 2/3. After a period of public comment and scientific review, a final position document (PD 4) is published delineating EPA's actual regulatory decision.

Table 20--U.S. average farm retail pesticide prices 1/

Pesticide	1984	1985	1986	Change 1985-86
	Dollars per pound 2/			Percent
Herbicides:				
Alachlor	5.18	5.15	5.10	-1.0
Atrazine	2.20	2.04	2.14	4.9
Butylate+	3.40	3.13	3.10	-1.0
Cyanazine	4.42	4.56	4.55	- .2
Metolachlor	6.15	6.09	6.05	- .7
Trifluralin	6.90	6.42	6.25	-2.6
2,4-D	2.44	2.38	2.26	-5.0
Composite 3/	4.15	4.06	4.05	- .2
Insecticides:				
Carbaryl	3.72	3.84	3.91	1.8
Carbofuran	10.32	10.30	10.27	- .3
Chlorpyrifos	8.36	8.22	8.30	1.0
Fonofos	8.62	8.85	8.82	- .3
Methyl parathion	2.89	2.88	3.00	4.2
Phorate	6.15	6.56	6.54	- .3
Synthetic pyrethroids 4/	55.60	54.60	51.20	-6.2
Terbufos	9.42	9.81	9.79	- .2
Composite 3/	9.98	10.52	10.32	-1.9

1/ Based on survey of farm supply dealers conducted by the National Agricultural Statistics Service, USDA. 1984 and 1985 prices are a simple average of March and May prices. 1986 is the April price. 2/ Active ingredient. 3/ Includes above materials and other major materials not listed. 4/ Weighted average of fenvalerate and permethrin prices.

Special Reviews by EPA

Common Name	Category	Major Use	Possible Risk	Status
Alachlor	Herbicide	Corn, soybeans, peanuts	Carcinogen	PD 2/3, September 1986
Aldicarb	Insecticide, nematicide	Peanuts, potatoes, cotton, citrus	Acute toxicity	PD 2/3, August 1986
Amitrole	Herbicide	Non crop areas	Carcinogen	PD 2/3, late 1987
Cadmium	Fungicide	Golf courses	Carcinogen, birth defects, fetal death	PD 2/3, late 1986
Captafol	Fungicide	Apples, citrus, potatoes, tomatoes	Carcinogen	PD 2/3, being prepared. No date schedule.
Captan	Fungicide	Fruits and nuts, vegetables, ornamentals	Carcinogen	PD 4, late 1987
Carbofuran	Insecticide	Corn, peanuts, sorghum, sunflowers	Wildlife, bald eagles	PD 2/3, late 1986
Cyanazine	Herbicide	Corn, sorghum, cotton	Birth defects	PD 2/3, late 1986
Daminozide	Growth regulator	Apples, peanuts	Carcinogen	Awaiting results of oncogenicity, mutagenicity, and metabolism studies.
Dinocap	Fungicide	Apples	Birth defects	PD 2/3, late 1986
Linuron	Herbicide	Corn, fruits, vegetables	Carcinogen	PD 2/3, late 1987
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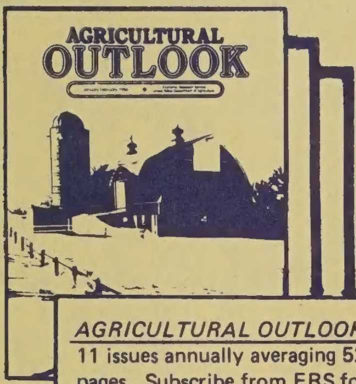

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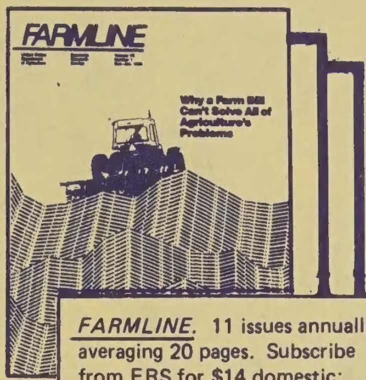

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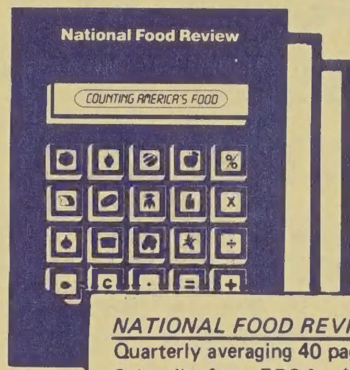

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